THE

ONTARIO WATER RESOURCES

COMMISSION

REPORT

ON A

GROUND WATER SURVEY

FOR THE

CITY OF KITCHENER

IN THE

COUNTY OF WATERLOO

1963

135 ST. CLAIR AVE. WEST - TORONTO

KITCHENER

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Ground Water Survey
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INTRODUCTION

In a letter dated March 16, 1963, R. K. Pequegnat, Superintendent of the Kitchener Water Commission, requested the assistance of the OWRC in determining the direction of future well-field expansion. Mr. Pequegnat explained that the recent attention given to water-supply problems in London had been reflected in Kitchener and had given rise to statements that the city's well supplies could be limited.

Between July 11 and November 12, 1963, a total of approximately 44 man-days were spent in the field examining the geology, locating recorded wells, and collecting samples of water for chemical analysis. The well data are listed in Table 1, the chemical analyses of water samples are listed in Table 2, and the locations of the wells are shown on the accompanying maps.

WELL NUMBERING SYSTEM

Wells are located by lot, concession, and township, or by the town or city in which they were drilled and are numbered chronologically within a lot, town, or city.

e.g. Well 61-3 in Lot 115, G.C.T. was the third well drilled in 1961 in Lot 115 of the German Company Tract.

Well 47-7 in Kitchener was the seventh well drilled in 1947 in Kitchener.

In Table 1, the municipalities and main divisions are listed alphabetically and the wells within these are listed numerically by concession, lot, year, and order within the year. Lot lines are shown on the map to aid in locating the wells.

PRESENT WATER SUPPLY

Kitchener obtains water from 21 wells all of which were constructed to extract water from aquifers in the overburden. Two additional wells, known as wells 15 and 42, normally are not used. Well 15 was drilled into the rock and yields poor quality water.

The wells are grouped into five areas or well fields. These are listed below:

Well Field	No. of Wells	Yield Million gpd
Shoemaker	6	4.7
Strange (not including Well 15)	7	2.8
Mannheim	5	4.6
Parkway	2	2
Guelph St. (Well 41 only)	1	0.21
	Total Yield	14.3

In 1962 the average pumpage was 7.75 million gpd and the maximum pumpage in a single day was 12.09 million gallons.

PREVIOUS WATER EXPLORATION PROGRAMS

The original water works plant was constructed in 1888 by the firm of Moffatt, Hodgins and Clarke, of Syracuse, N.Y. This firm operated the system under the name of 'The Berlin Water-works Company' until 1898 when it was purchased by the city. The original source of supply was a spring lake known as Shoemaker Lake located at the site of the Shoemaker well field. In 1899 a supply of ground water was established at the Shoemaker Avenue site and the

natural flow from wells was used as a source of supply. By 1903 the natural flow from the wells proved to be inadequate and an air lift system was installed to pump them.

Since the establishment of the water supply from wells at Shoemaker Avenue, test drilling has been carried out over a wide area within and surrounding the city. In 1915, wells were drilled in the Bridgeport area and in 1920 to 1923 a well field was developed in the Strange Street area.

During the years 1942 to 1949, inclusive, an extensive test-drilling program was carried out in the areas within five miles of the city. This resulted in the locations of aquifers in the Mannheim and Parkway areas. Four wells were constructed in the Mannheim area in the period 1950 to 1953 and a fifth in 1962, but it was not until 1959 and 1960 that the two wells in the Parkway area were constructed.

GEOLOGY

Bedrock

The elevation of the bedrock surface in the map area varies mainly between 800 and 1000 feet. The bedrock topography is illustrated on Map 2 by means of contours representing elevations above sea level on the bedrock surface. The contours indicate the presence of a dissected ridge that extends from the Petersburg area, through the business section of the city to the Breslau area. The contour map also indicates the presence of at least two bedrock valleys or depressions that extend to the southeast from and at right angles to the bedrock ridge.

The rock formations that occur at the bedrock surface are of Silurian age and dip gently to the west. The following is a brief description of the Silurian formations, which are listed in chronological order with the

youngest at the top. Only the Saline and Guelph formations occur at the bedrock surface.

Formations or Group Formations	Description
Saline	Buff to brown dolomite and limestone, grey dolomitic shale, anhydrite, gypsum, and salt.
Guelph	Cream to buff dolomite.
Lockport	Buff to grey dolomite.
Clinton and Cataract	White and grey sandstones, grey shale, and buff dolomite.

Strata of the Saline formation occur at the bedrock surface in all but the extreme southeastern area of the map and in the bedrock depression that occurs in the Centreville area. The Guelph formation occurs at the bedrock surface in these areas and under the Saline formation in the rest of the area. The interpreted location of the contact between the Saline and Guelph formations at the bedrock surface is shown on Map 2.

The Lockport formation does not occur at the bedrock surface in the area but it is present under the Guelph formation and may be intersected by some of the deeper rock wells east and southeast of Breslau.

The only rock outcrops in the area are along the floor of the Speed River valley but the bedrock surface probably is less than 30 feet below the Grand River in the Breslau area.

Overburden

Most of the overburden materials were deposited in Pleistocene times. They generally have a thickness of 150 feet or more and in many areas west and southwest of Kitchener the thickness is over 350 feet. The overburden appears to be thinnest near the Grand River in the Breslau area where it probably has a thickness of less than 30 feet, and along the floor of the

Speed River valley at the eastern limit of the map area where it is absent locally.

The overburden deposits in the eastern half of the map area are described by P. F. Karrow in the "Pleistocene Geology of the Galt Map Area", Ontario Department of Mines, Geological Circular No. 9. —

The materials that were deposited by ice are generally a heterogeneous mixture of clay, silt, and sand, with or without stones and boulders, called till. The materials deposited by meltwater comprise relatively well-sorted sand and gravel, with silt and clay occurring in areas where the water was ponded.

Till probably is the most extensive of the overburden materials, P. F. Karrow has described three tills in the eastern half of the map area and suggests that other till sheets may be present below them. The lowest of the three tills is described as a dense, sandy to silty, stony till with a grey-buff to olive colour and exposures show that it is overlain by an often contorted varved clay or a dark grey, clay till with a reddish or brownish tint. The uppermost till, called the Wentworth till by Karrow, is fine to coarse sandy till. According to Karrow, analyses of the three tills indicate that they were deposited by westward moving ice from the Lake Ontario basin. He feels that the Wentworth till does not extend westward beyond Kitchener. It is possible that the two lower tills extend westward beyond the Wentworth till into the area west of Kitchener and Waterloo. A dense, silty, stony till with a grey-buff colour can be seen in most sections west of Kitchener, whereas the till in the Mannheim-Williamsburg area is a reddish brown, silty, clay till with stones.

Driller's logs indicate the existence of lower tills that probably do not outcrop in the map area; however, it is not possible to determine how many of these are present because in many cases the descriptions are insufficient to determine whether the materials intersected are till or lacustrine deposits.

The overburden in the Kitchener area is characterized by an abundance of sand and gravel in the form of outwash and kame deposits. Large deposits can be seen at the surface in areas adjacent to the Grand River and west of Kitchener and buried deposits within the overburden occur throughout the area. The deposits are thickest near Mannheim, Breslau, immediately west of Waterloo, and immediately west of the map area near Baden. The largest continuous sand and gravel deposit outcrops just east of Mannheim where it is over 200 feet thick. It can be traced by means of well logs from an area about one mile east of Saint Agatha to an area about two miles southeast of Mannheim. It ends abruptly on the west but although it becomes thinner to the east it probably extends in an irrigular manner to the Shoemaker Avenue and Williamsburg areas and it is possible that the buried gravel deposit in the Parkway area is a continuation of it. At Mannheim the deposit is current-bedded and passes upward into sand. In most places it is overlain and underlain by till but a test hole (Well No. 59-1 in Lot 2, Con. SRS, Wilmot township) south of Highway 7 indicates that it rests directly on the bedrock in this area.

Deposits of sand with some gravel occur within the overburden west and northeast of the large Mannheim gravel deposit. The hilly area south and east of Baden is composed of sand in which the stratification generally dips to the north. Away from the Baden hills the deposit occurs under till. In places near Petersburg it appears that there are two layers of sand separated by clay; however, it is not known whether the two are different deposits or whether they are the same and contain lacustrine clay.

The sand deposit immediately west of Kitchener and Waterloo and northeast of the Mannheim gravel deposit is over 200 feet thick in places. This sand probably was laid down at the same time as the sand to the west in the Baden and Petersburg area.

The southern edge of a gravel deposit in the Breslau area appears to be oriented in a northwest-southeast direction parallel to the contours on the southwest side of the bedrock ridge. It extends to the northeast around the areas with high bedrock. The deposit seems to occur between 900 and 950 feet above sea level. Its distribution suggests that it was deposited as a kame terrace with ice to the south and high bedrock to the northeast.

Thin deposits of sand and gravel occur within the overburden near Centreville and in the lower part of the overburden in places west and southwest of Kitchener.

It is likely that the bedrock depressions described in the section on bedrock and illustrated on Map 2 have been modified by the gouging action of ice and that the bedrock ridge that extends from Breslau to Petersburg marked the approximate northwestern limit of ice from the Lake Ontario Basin. The thick deposits of sand and gravel in the area tend to support this idea.

AQUIFERS

Bedrock Aquifers

The Salina, Guelph, and Lockport formations form an aquifer capable of yielding abundant supplies of water; however, the Salina formation yields water with a chemical quality that is inferior for municipal purposes and for this reason it will not be considered as a source of water supply for the city. The approximate location of the eastern limit of the Salina formation is shown on Map 2.

East of the Salina formation the Guelph and Lockport formations constitute one of the best and most extensive bedrock aquifers in Ontario. It is from this aquifer that Galt, Guelph, Hespeler, and Preston, obtain large amounts of water. Some wells in the aquifer yield more than 1000 gpm, but in many locations the rock is not as pervious and the yield of wells may be less than

50 gpm. The yield of some of these wells might be improved by applying acid under pressure to enlarge the openings in the rock in the area immediately surrounding them.

The Guelph and Lockport formations are present throughout the whole of the map area; however, it is unlikely that they would yield fresh water suitable for municipal supply except in areas east of the Grand River. This will be considered further in the sections on " Water Quality " and " Ground Water Flow ".

Graphs 1 and 2 show the water levels in the bedrock aquifer in the Shoemaker and Strange well fields. The graphs illustrate that the water level in the aquifer varies according to the amount of precipitation. They also suggest that the water level has declined about five feet in the Shoemaker and Strange well field over the period from 1947 to 1963, inclusive. The decline amounts to about 0.3 feet per year but is particularly noticeable in the period from 1957 to 1963, when the amount of precipitation was less than in previous years. The removal of water from industrial rock wells may have contributed to the decline but it is doubtful if the removal of water from the overburden aquifers by the municipal wells has been a direct cause. The continued decline of the water level in 1958 and 1959 after the pumpage from the Shoemaker wells was decreased suggests this, although there was also a decrease in precipitation compared to the two preceeding years.

Overburden Aquifers

The sand and gravel deposits are the aquifers in the overburden whereas the deposits that contain mainly clay or silt are the aquicludes or confining layers; however, the classification of these deposits into aquifers and aquicludes is not simple because there can be a complete gradation from one to the other.

For purposes of simplicity the overburden aquifers are here divided into the upper, middle, and lower groups. The classification is based on the location of the aquifer within the sequence of overburden materials but does not necessarily imply continuity or hydraulic connection within a group.

Upper Aquifer Group

The upper aquifer group is equivalent to the most recent deposits of sand and gravel which include outwash along the flanks of the Grand River, kame deposits in the Breslau-Doon area, and the thin deposit of sand or sand and gravel that occurs throughout the built up sections of Kitchener. Although these sand and gravel deposits are over 100 feet thick in places, the saturated thickness is usually only a few feet if water is present at all. Most domestic drilled wells, except those in the Centreville area, are drilled through the upper aquifer into the lower aquifers. Because of this it is unlikely that large quantities of water could be pumped from the upper aquifer by means of conventional screened wells.

Although there are extensive deposits of sand and gravel adjacent to the Grand River, particularly in the area south of Breslau, available information suggests that the sand and gravel does not contiue under the river; therefore, it is unlikely that a supply of filtered river water could be obtained by means of an infiltration gallery constructed in the upper aquifer group.

Middle Aquifer Group

The middle aquifer group contains the main aquifers in the area. It differs from the upper aquifer group because it was deposited prior to the last advances of ice and for the most part is covered by till and in places by the upper aquifer group. Wherever two buried aquifers occur the upper one is here considered part of the middle aquifer group but it

is difficult to differentiate between the two groups when only one is present because both are generally buried and in places either may rest directly on the bedrock.

The middle aquifer group includes most of the large deposits of sand and gravel described in the preceeding section on the geology of the overburden. There are two types of aquifers in the group, those composed mainly of sand and gravel and those composed of sand. The sand and gravel aquifers include the large deposit between Saint Agathe and the Mannheim area, and deposits in the Shoemaker Avenue, Strange Street, Parkway, and Bridgeport-Breslau areas. Henceforth, in this report these will be referred to as the Mannheim, Shoemaker, Strange, Parkway, and Breslau aquifers. The aquifers that are composed mainly of sand include deposits in the Petersburg-Baden area and in an area immediately west of Kitchener and Waterloo in the vicinity of Erb Street and Highway 7. These aquifers will be referred to as the Petersburg and Erb Street aquifers. The locations of the aquifers are shown on Map 2.

Mannheim Aquifer

The Mannheim aquifer can be outlined fairly accurately from well and test hole data except in areas to the east where it cannot be established clearly by means of well logs whether the aquifer continues as the Shoemaker, Strange, and possibly the Parkway aquifers. The deposit is thickest in the upland area immediately east of Mannheim where at least 200 feet of sand and gravel are present; however, the saturated thickness at this location is probably only about 50 or 60 feet. Conditions in the aquifer vary from artesian to water table. It is under water table conditions where it outcrops and in thick sections adjacent to outcrops. In the east half of Lot 148, GCT, where the aquifer can be seen in a gravel pit it probably is dry.

For the most part, the aquifer rests on clay but near the intersection of Highway 7 and the Waterloo-Wilmot township line it rests on rock. This is indicated by the log of Well 59-1 in Lot 2, SRS, Wilmot township. It is possible that, at this location, the aquifer is composite and rests directly on a lower aquifer.

International Water Supply, Limited, have carried out a number of pumping tests in the aquifer. Their analyses of the tests indicate that the coefficient of transmissibility is as high as 585,000 gpd per foot locally but generally varies between 20,000 and 70,000 gpd per foot.

Kitchener and Waterloo pump water from this aquifer by means of wells near Mannheim and Saint Agatha, respectively, and both cities have established additional well sites between their well fields.

Shoemaker Aquifer

The Shoemaker aquifer is composed of sand and gravel. It is generally between 30 and 70 feet thick and is confined beneath silty clay. Locally the aquifer is composed mainly of s and with thin bands of gravel. The first wells drilled in this area used to flow but the static levels are now below ground level. Graph 3 is a record of the static levels in the Shoemaker wells. It is apparent from the graph that the static level has declined but it is difficult to specify the rate of decline because of the flustuations which appear to be related to precipitation. It may be about 1.5 feet per year if the last readings for Wells 3, 5, and 6 are ignored. The reason for the abnormally low water levels in wells 3, 5, and 6 is not known.

It is likely that this aquifer is connected hydraulically to the Mannheim aquifer, which probably is the recharge area.

Strange Aquifer

The Strange aquifer located in the northwestern section of Kitchener is composed of sand and gravel and is under artesian conditions. It probably is connected hydraulically to the Mannheim, Shoemaker, and Erb Road aquifers and the Waterloo aquifer to the north from which the Waterloo wells obtain water. There is insufficient data to construct a graph of the static levels in the Strange wells but measurements indicate that the static level is declining at a rate of less than one foot per year.

Parkway Aquifer

The Parkway aquifer is composed of sand and gravel with a maximum known thickness of 30 feet. The aquifer is under artesian conditions. It may be connected hydraulically with the Shoemaker and Mannheim aquifers to the west and it likely outcrops along the bank of the Grand River near the new Highway 8 bridge. Borings done by E.M. Peto Associates Limited at this location for the Department of Highways intersected about 15 feet of sand and gravel below the river. The deposit is beneath till in places indicating that it belongs to the middle or lower aquifer group. It is possible that the aquifer has a thickness of more than 15 feet under the river nearby but additional testing would be necessary to prove this. If 25 or 30 feet of the aquifer is present under the river it may be possible to construct an infiltration system in this area. Graph 4 is a plot of the water level in this aquifer measured in Well 55-1 in Kitchener.

Breslau Aquifer

The Breslau aquifer consists of a water-bearing sand and gravel deposit between Bridgeport and the area east and south of Breslau.

It is generally under artesian conditions but it outcrops in places along the banks of the Grand River west of the Wellington-Waterloo Airport. One of the airport wells and wells at Hopewell Farm and a subdivision near Breslau obtain water from this aquifer. It may be possible to obtain filtered river water by means of shallow wells or an infiltration system where this aquifer passes under the river but test drilling would be necessary to determine if the aquifer was thick enough for such an installation.

Petersburg and Erb Street Aquifers

The Petersburg and Erb Street aquifers are composed mainly of sand with silt in places. Both aquifers are under water-table conditions throughout most of their extent. The aquifers are tapped by domestic wells but it is unlikely that wells comparable in capacity with the Mannheim wells could be constructed in them.

Lower Aquifer Group

The lower aquifers are composed of sand or sand and gravel and have a maximum thickness of 40 feet. The most continuous member occurs beneath till under and west of the Mannheim aquifer in the area south of Mannheim and Petersburg and it may form the basal section of the Mannheim aquifer in the vicinity of Highway 7. There are no municipal wells in it in these areas, therefore, it is a potential source for additional ground water. The aquifer seems to occur within about 50 feet of an elevation of 900 feet above sea level. It is possible that the Parkway and Breslau aquifers belong to this group.

WATER QUALITY

The chemical analyses of samples of water taken from wells are listed in Table 2.

In general, the water is hard and in places has a high iron content but otherwise it is satisfactory for municipal use. Exceptions include those samples taken from rock wells west of the Grand River and from overburden wells near the Grand River at Bridgeport and in the Doon area.

The hardness in the overburden aquifers generally is within the range of 250 to 500 ppm. When averaged for each aquifer the analyses indicate that the softest water in the overburden aquifers occurs in the Petersburg, Mannheim, and Parkway aquifers whereas the hardest water occurs in the Waterloo, Strange, and Shoemaker aquifers. These results exclude the sections of the overburden aquifers adjacent to the Grand River at Bridgeport and near Doon where extremely hard water occurs. The reason for the occurrence of hard water in the overburden aquifers at these locations is explained in the following section on " Ground Water Flow ".

The hardness in the rock aquifers east of the Grand River averages about 350 ppm and as such is comparable with water from the Strange and Shoemaker aquifers. West of the Grand River, water from the bedrock is extremely hard and locally exceeds 1700 ppm hardness. The hardness probably is caused by the evaporite deposits in the Salina formation.

With the exception of the Petersburg, Mannheim, and Shoemaker aquifers all the aquifers in the map area contain water with an iron content in excess of the recommended maximum of 0.3 ppm. The iron content is highest in rock aquifers, both east and west of the Grand River. Among the over-

overburden aquifers water in the lower aquifer, below and to the west of the Mannheim aquifer, contains the most iron.

GROUND WATER FLOW

Precipitation is the source of ground-water recharge. The portion that reaches the zone of saturation flows through the ground usually from upland areas and discharges into streams, rivers, and lakes and much eventually returns to the ocean. In certain areas the process is reversed locally and influent seepage takes place from streams. Ideally, a drainage basin may be divided into areas or centres of recharge, areas of ground-water transmission, and areas of discharge; however, recharge may still take place in the area of ground-water transmission and the flow pattern may be complicated by local irregularities. Ground-water flow in a large drainage basin can be subdivided to conform largely with major rivers and their various tributaries. Thus, a large river may receive ground-water discharge or base flow from a large area but its tributaries normally receive base flow from smaller areas. In the case of base flow to a river the water may have entered the ground many miles away and passed through deeper aquifers.

In the Kitchener area, the floors of the Grand and Speed River valleys are the main ground-water discharge zones and the rivers receive ground water from the rock aquifers in addition to that from the local overburden aquifers. The recharge centres west of the Grand River are the highland areas south and west of the city, in particular, the highland area east of Mannheim between Kitchener and Saint Agatha. East of the Grand River, the recharge centre is probably in the extreme northeast section of the map area.

The regional flow of ground water is towards the Grand and Speed Rivers but the direction may be modified locally as in the area between Petersburg and Mannheim where the ground water flows towards the southwest to discharge

into Alder Creek. The Mannheim aquifer outcrops near the creek in this area which is shown on the National Topographic map as a marshy area.

With a knowledge of the ground-water flow it is possible to understand some of the variations in the quality of water. Thus, the softest water occurs in recharge areas, such as the Petersburg and Mannheim aquifers, and the hardness increases east of the Mannheim aquifer as water moves in this direction through more overburden material until in the Shoemaker, Strange, and Waterloo aquifers the hardness is at least 100 ppm more than at Mannheim. The hardness of water in the Parkway aquifer is similar to that at Mannheim which suggests that the Parkway aquifer may not be connected to the Shoemaker aquifer.

East of the Grand River, water in the rock has a hardness comparable to the overburden. It is likely that most of this water has flowed westward through the Guelph and Lockport formations whereas on the west side of the river water from the rock has passed eastward through the Saline formation and is extremely hard.

The distribution of iron is similar to hardness in that water with the least iron is in the recharge areas and water containing the most iron is present in the rock aquifers.

Much of the ground water that is discharged into the Grand and Speed Rivers has flowed a long way, deep in the ground, and has dissolved more of the aquifer materials. This probably explains the extremely hard, and in places sulphurous, water that occurs even in overburden aquifers adjacent to these rivers. The water yielded by the old Bridgeport wells, overburden wells in the Doon area, and Preston's Well 5 (well 50-1 in Preston) is an example of this.

GROUND WATER RECHARGE AND AVAILABILITY

The area west of the Grand River appears to be favourable for ground-water recharge. Gravel and sand deposits are abundant and in many places appear as inliers surrounded by clay till. In such places where the gravel is at a lower elevation than the till, runoff from the till areas would be directed toward the gravel areas which would permit the infiltration of water more readily.

The amount of ground-water recharge is subject to so many variables that it is difficult to calculate accurately. It was found that there were insufficient data available in the Kitchener area to determine the amount of recharge accurately; however, it is possible to make an approximate estimate.

Graph 5 represents the daily flows in cubic feet per second in Laurel Creek 25 feet downstream from the Weber Street bridge in Waterloo. At this point the flow represents drainage from an area of 23 square miles. Laurel Creek was used for study because it is the only creek in the area for which data are available. The data were supplied by the Department of Northern Affairs and National Resources.

It was assumed that the low flows on the graph represent base flow and that the area below a line connecting the low flows would represent the base flow quantitatively. The lowest base flows occur during the summer months probably because part of the ground water that would have discharged into the creek is lost as evapo-transpiration. The broken line shown on the graph for the summer period was designed to represent what the base flow would have been if noneof the ground water had been lost to evapo-transpiration. The base flow, runoff, and the difference between precipitation and flow, which probably represents evapo-transpiration approximately, were calculated from this graph for the years 1960 and 1961 when the data were most complete. They are listed in the following table together with the precipitation:

	1960	1961
Precipitation		
Inches	35.0	30.4
Million gpd/sq.mi.	1.4	1.2
Mean Daily Flow in Laurel Creek		
cfs.	17.4	12.4
Million gpd	9.2	6.6
Million gpd/sq. mi.	0.40	0.29
Precipitation Minus Flow		
Million gpd/sq. mi.	1.0	0.9
Percent of precipitation	72.0	76.0
Base Flow		
Net base flow. Million gpd/sq. mi.	0.065	0.073
Gross base flow. Million gpd/ sq. mil (Net base flow plus ground-water believed lost to evapo-transpiration)	0.08	0.08
Percent of Precipitation (Net base flow)	4.5	6.0
Surface Runoff		
Million gpd/sq. mi. (Flow minus net base flow)	0.33	0.22
Percentage of precipitation	23.5	18.0

The precipitation minus flow probably is approximately equivalent to evapo-transpiration but it also includes the amount of water removed by wells and the water that passes out of the area through aquifers.

The average precipitation at Kitchener over a 23-year period was 31.19 inches. This is only 0.79 inches higher than the precipitation for 1961; therefore, the figures calculated for 1961 are used to represent average conditions. If Laurel Creek is a "balanced" drainage basin in which the gross annual base flow is equivalent to the annual recharge, the recharge in the area would be 80,000 gpd, per square mile or 7.6 percent of the precipitation. This is comparable with the recharge rate of 82,500 gpd per square mile calculated for Dupage County, Illinois, which is a similar area. The findings of that survey are published as "Cooperative Ground-water Report 2" of the State Water and State Geological Surveys of Illinois.

The average daily withdrawal of ground water for use in Kitchener and Waterloo in 1962 was approximately 12 million gpd. This is equivalent to average daily pumpages of 7.75 and 2.15 million gallons for Kitchener and Waterloo, respectively, and an allowance of 2.1 million gpd for industrial use. If the recharge rate in the area amounted to 80,000 gpd per square mile as indicated by the stream flow data for Laurel Creek, recharge from 150 square miles of land would be required to sustain the estimated 1962 pumpage of 12 million gpd. The geology and the distribution of streams in the area suggests that the recharge area is approximately 50 square miles, which is only 33 percent of the area calculated from the stream flow data. The withdrawal is equivalent to a recharge rate of 0.24 million gpd per square mile or 19 percent of the precipitation if the aquifers are not being mined. The estimated recharge area of 50 square miles is bounded to the north by Laurel Creek and its tributary at Erbsville, to the west by the western boundary of the Mannheim

aquifer, to the south by a line drawn from a point about 1 mile south of well 51-1 in Lot 3, BRS, Wilmot township (Kitchener's Well 24) to the Grand River east of Strasburg, and to the east by a line joining Bridgeport and the Grand River about 4000 feet southeast of the Parkway wells.

There may be several reasons why there is a large discrepancy between the recharge rate calculated from the stream flow data and that calculated by pumpage from the estimated recharge area. These are listed below:

1. The recharge area may be greater than 50 square miles.
2. The recharge calculated from the Laurel Creek data may be incorrect in that more of the precipitation may enter the aquifers and flow out of the drainage basin or towards high capacity wells in Waterloo.
3. The recharge rate calculated from the Laurel Creek data may not be representative of the whole map area.
4. Although the water levels in the aquifers are lowered by pumpage they may recover completely in the spring of the year, thereby reducing the amount of base flow to the creeks throughout much of the year and promoting maximum recharge.
5. The aquifers are being mined.

Of the five reasons listed above it is doubtful if the first is very significant. It is possible that the recharge area could be enlarged by a few square miles but this would not reduce the discrepancy between the two calculated recharge rates by much.

The Mannheim aquifer outcrops in the Alder Creek basin and may allow more recharge to enter the ground than the deposits in the Laurel Creek basin. In addition, the water in the Erb Street aquifer, which now flows

towards the Waterloo and Strange Street wells, probably discharged into Laurel Creek at one time.

A maximum amount of ground water could be obtained from an aquifer by lowering the water level and reducing the base flow. This would make more room in the aquifer for recharge but the amount of water available on a perennial basis would depend on the recharge rate. The decline of the water level in the Shoemaker aquifer, illustrated in Graph 3, suggests that the rate of ground-water extraction may exceed the average recharge rate and that the aquifer is possibly being mined slowly.

FUTURE DEVELOPMENT OF GROUND WATER SUPPLIES

In the preceeding section it was suggested that the overburden aquifers that have been tapped by the main municipal wells in the Kitchener-Waterloo area are possibly being mined by the withdrawal of approximately 12 million gpd. The decline of water levels in the Strange and Shoemaker aquifers suggests that the withdrawal is in excess of the recharge rate. Very little is known about the water levels in the Mannheim aquifer because most of the wells and gauge holes are along the flanks of the aquifer where the water level remains relatively constant. It is likely that the Mannheim aquifer is connected hydraulically to the aquifers to the east and that it is being used to capacity; however, records of water levels in wells located in the upland areas where the aquifer is under water-table conditions should provide more information about this. It might be possible to increase the amount of water available in these aquifers by constructing dams in the discharge zones of Alder and Laurel Creeks but a cost-benefit study would be necessary to show if such a project would be worthwhile.

Unless it is shown by subsequent observation that more water can be pumped perennially from the present well fields it will be necessary to

seek future ground-water supplies in other aquifers. The Petersburg aquifer to the west of Mannheim is composed mainly of sand and, because of this, it is unlikely that individual wells with capacities similar to the present Mannheim wells could be constructed; however, the quality of the water in this aquifer is probably the best in the Kitchener-Waterloo area.

An aquifer in the lower part of the overburden, described in the chapter "Aquifers" under the heading "Lower Aquifer Group", occurs below and to the west of the Mannheim aquifer south of Mannheim and Petersburg. It has not yet been explored to determine its potential as a source of municipal water supply. The hardness of the water in this aquifer is comparable to the water pumped from the Shoemaker and Strange aquifers but it appears to have a higher iron content.

It should be possible to obtain more water from the Breslau aquifer to the east of Kitchener. The city's wells 41 and 42 (wells 37-7 and 45-2 in Kitchener) are constructed in this aquifer but the aquifer extends eastward across the Grand River as shown on Map 2. The quality of water from this aquifer is satisfactory for municipal purposes but in places it has a high iron content.

The rock aquifer in the area east of the Grand River is a potential source of water supply; however, chemical analyses show that water from it contains iron in excess of 1.0 ppm. This would require treatment if it were used as a source of supply for the city.

If wells were to be constructed in the Breslau aquifer or the rock east of the Grand River it would be preferable to locate them away from the river because the river is a major discharge zone and the ground water close to it may be extremely hard and sulphurous. The old Bridgeport wells,

Preston's Well 5 (well 50-1 in Preston) and certain overburden wells in the Doon area are examples of this.

In places where the middle of upper aquifers occur under the Grand River it may be possible to construct infiltration systems. It would be necessary to test drill to determine if this were possible but the available information suggests that areas adjacent to the river at the following locations would be most favourable.

1. German Company Tract, Lot 117, 119, and 120.
2. Beasley's Broken Front, Lot 12.
3. Kitchener from the new Highway 8 bridge to an area about 4000 feet downstream.

The quality of the water in the Grand River would be an important factor if an infiltration system were to be used to obtain a water supply. The sand below the river would filter the solids and remove the BOD caused by the solids but it would be preferable to locate a gallery or collector where the BOD is least. Of the locations described above, the one downstream from the new Highway 8 bridge would be most favourable because it is upstream from the outfall of the Kitchener sewage treatment plant and more than nine miles downstream from the outfall of the Waterloo sewage treatment plant. In addition, it is possible that phenols that enter the river via Canagagigue Creek would have evaporated before the water reached the Highway 8 bridge.

SUMMARY AND CONCLUSIONS

At the present time Kitchener and Waterloo obtain water from overburden aquifers by means of wells within five miles of the city centres. In 1962 the average withdrawal from these aquifers amounted to approximately 12 million gpd.

Although the aquifers from which the wells obtain water have been considered and named separately, it is likely that they are all connected hydraulically with the exception of the Breslau aquifer and perhaps the Parkway aquifer. It appears that most of the water in the aquifers flows towards the Grand River, which is the main ground-water discharge zone.

It has been estimated that the recharge for the overburden aquifers that supply Kitchener and Waterloo comes from about 50 square miles of land and that most recharge comes from the area of the Mannheim and Erb Street aquifers. It has been calculated, by using Laurel Creek flow data, that base flow, which is probably indicative of the minimum ground-water recharge rate in the area amounts to 80,000 gpd per square mile. This is comparable to recharge rates calculated for a similar area in Illinois. The withdrawal of ground water in the Kitchener-Waterloo area exceeds this rate if it is assumed that the recharge area is 50 square miles. It may be that the calculated recharge rate is too low and that an allowance should be made for reduction in base flow as a result of ground-water withdrawals in the area. The possibilities exist also that recharge conditions are higher in the area immediately south of the Laurel Creek basin and that the lowered water levels in the vicinity of the Shoemaker Avenue and Strange Street wells indicate a mining of that aquifer.

It might be possible to increase the amount of water available within the area of the present well fields by constructing dams across Alder Creek at Mannheim and the upper reaches of tributaries of Laurel Creek, but a cost-benefit study would be necessary before such a project were carried out.

The amount of ground water that should be available is equivalent to a rate of at least 56 million gpd within 15 miles of the city centre. The figure is based on the calculated minimum recharge rate. In practice it

is unlikely that all the available water could be captured. In addition, other municipalities are interested in water resources in the same area.

Additional supplies of ground water may be available from overburden aquifers west of the Mannheim aquifer and in the Breslau area and from the bedrock east of the Grand River. The quality of water from the Petersburg aquifer should be best but the aquifer is mainly sand and it is doubtful if wells that would yield more than 300 or 400 gpm each could be constructed in this area. Water from other overburden aquifers and the rock east of the Grand River has a high iron content and may require treatment.

The chemical quality of water from the rock west of the Grand River is unsuitable for a municipal supply, because the hardness generally exceeds 1500 ppm, but could be used by some industries for cooling. Water used in this way would not be contaminated and could be returned to the ground.

It may be possible to obtain a supply of water from the Grand River by means of infiltration systems. The quality of such water would not be as good as the present supply and may require treatment.

Test drilling would be necessary to establish well sites in any of the aquifers referred to above or to establish a site for an infiltration system. The most favourable sites to test for infiltration works are described in the report and shown on Map 2.

RECOMMENDATIONS

The following are recommendations for the management of water resources in the Kitchener area.

1. In order to observe carefully the trends in ground-water levels in the Strange, Shoemaker, and Mannheim areas, observation wells should be established in each area. The present trend in the Strange and Shoemaker areas indicates that the ground-water levels are lowering and it will be necessary to deter-

mine if the aquifer is being overpumped or whether it is possible to operate the wells safely at a lower pumping level.

Observation wells should be drilled in the upland area east of Mannheim and in Lot 33, GCT, Township of Waterloo. These are recharge areas in the Mannheim and Erb Street aquifers, respectively. Because the water level may be different at different levels in the aquifers it is recommended that where possible two holes be drilled at each site, one to the base of the aquifer and the other to a depth 10 to 20 feet below the water table. The behaviour of the water level in these holes over a period of several years should help to indicate whether or not more water could be withdrawn permanently from the present wells and how many additional wells, if any, can be constructed in the aquifer. Existing gauge wells should be maintained and form part of the observation well network. It is doubtful if much information on the perennial yield of the aquifer could be obtained from gauge holes adjacent to Alder Creek because this is a discharge area and the water levels likely would remain nearly constant.

2. If the information obtained from the observation well data indicates that the aquifer is being mined no wells except replacement wells should be constructed in the Strange, Shoemaker and Mannheim areas.

3. Test drilling should be carried out to establish well sites in the Petersburg aquifer, the lower aquifer south and west of Mannheim, the Breslau aquifer, and the bedrock east of the Grand River.

4. Testing should be carried out in the areas adjacent to the Grand River shown on Map 2 to determine if an infiltration system could be constructed. Regular sampling of the Grand River and analysis for phenols should be undertaken as part of the testing program.

5. Industries that need water for cooling should take water from the bedrock and should return the water to the bedrock after use where such withdrawals seriously lower the ground-water levels.

6. The city should initiate a joint study with other municipalities in the area to determine the most efficient ways to jointly exploit the water resources of the area bearing in mind that at some future date it may be necessary to use both ground and surface sources of supply.

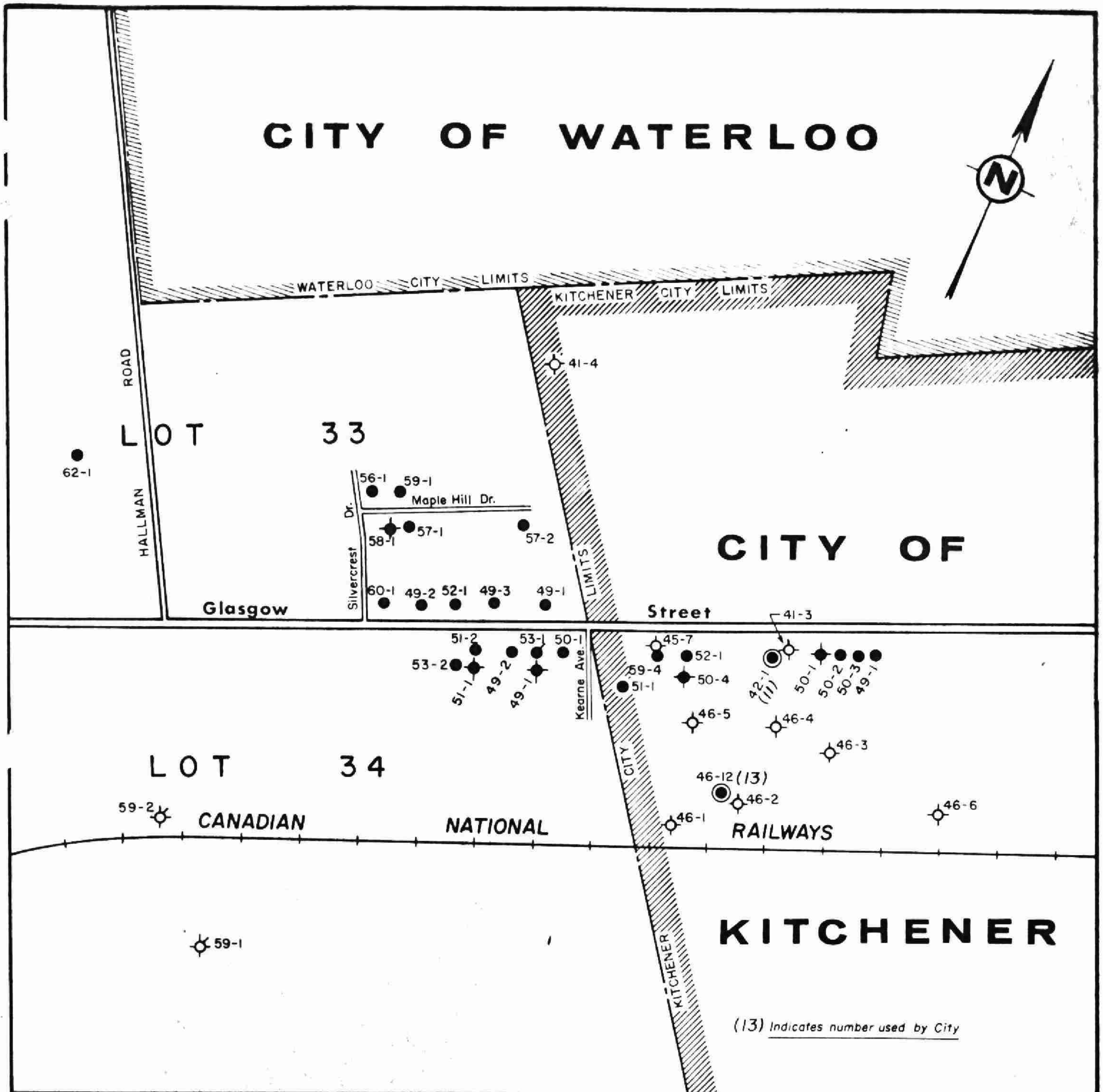
All of which is respectfully submitted,

Prepared by: V. R. Dixon.
Supervised by: D. H. Jeffs.

A. K. Watt, Director,
Water Resources Division.

Approved G. M. Galimbert
Ass't General Manager

/ph
Jan. 2, 1964.



LEGEND

- Drilled Overburden Well
- Drilled Rock Well
- Abandoned Well
- Test Well
- Municipal Well
- Dug or Bored Well

ONTARIO WATER RESOURCES COMMISSION

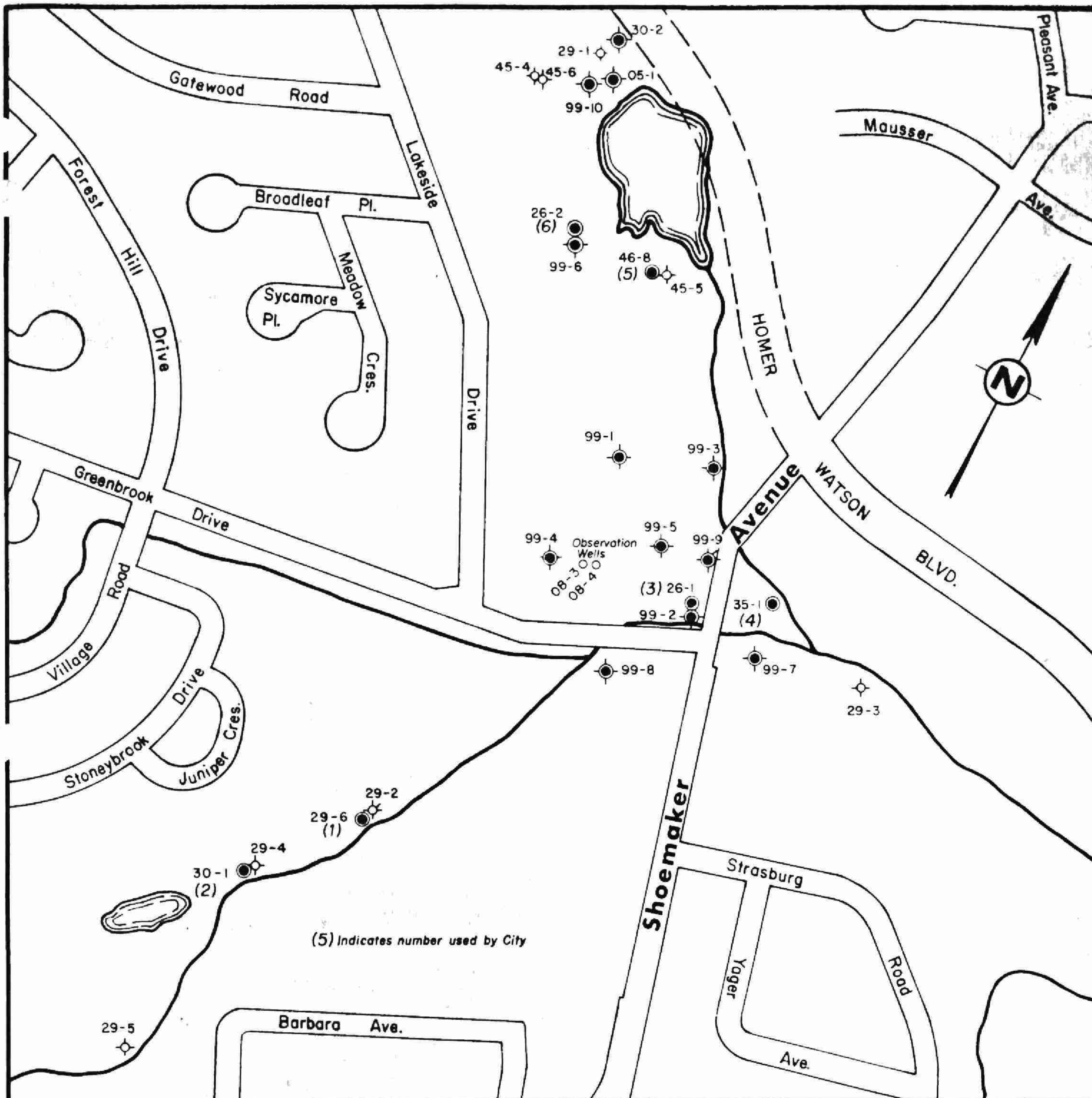
CITY OF KITCHENER

GROUND WATER SURVEY

— MAP № 3 —

Wells in Part of Lots 33 and 34 G.C.T.
— Township of Waterloo —
and in Part of the City of Kitchener

Nov. 1963 | Scale 1 Inch = 800 Feet | H.A.F.



LEGEND

- Drilled Overburden Well
- Drilled Rock Well
- Flowing Well
- Abandoned or Dry Well
- Test Well
- Municipal Well

ONTARIO WATER RESOURCES COMMISSION

CITY OF KITCHENER

GROUND WATER SURVEY

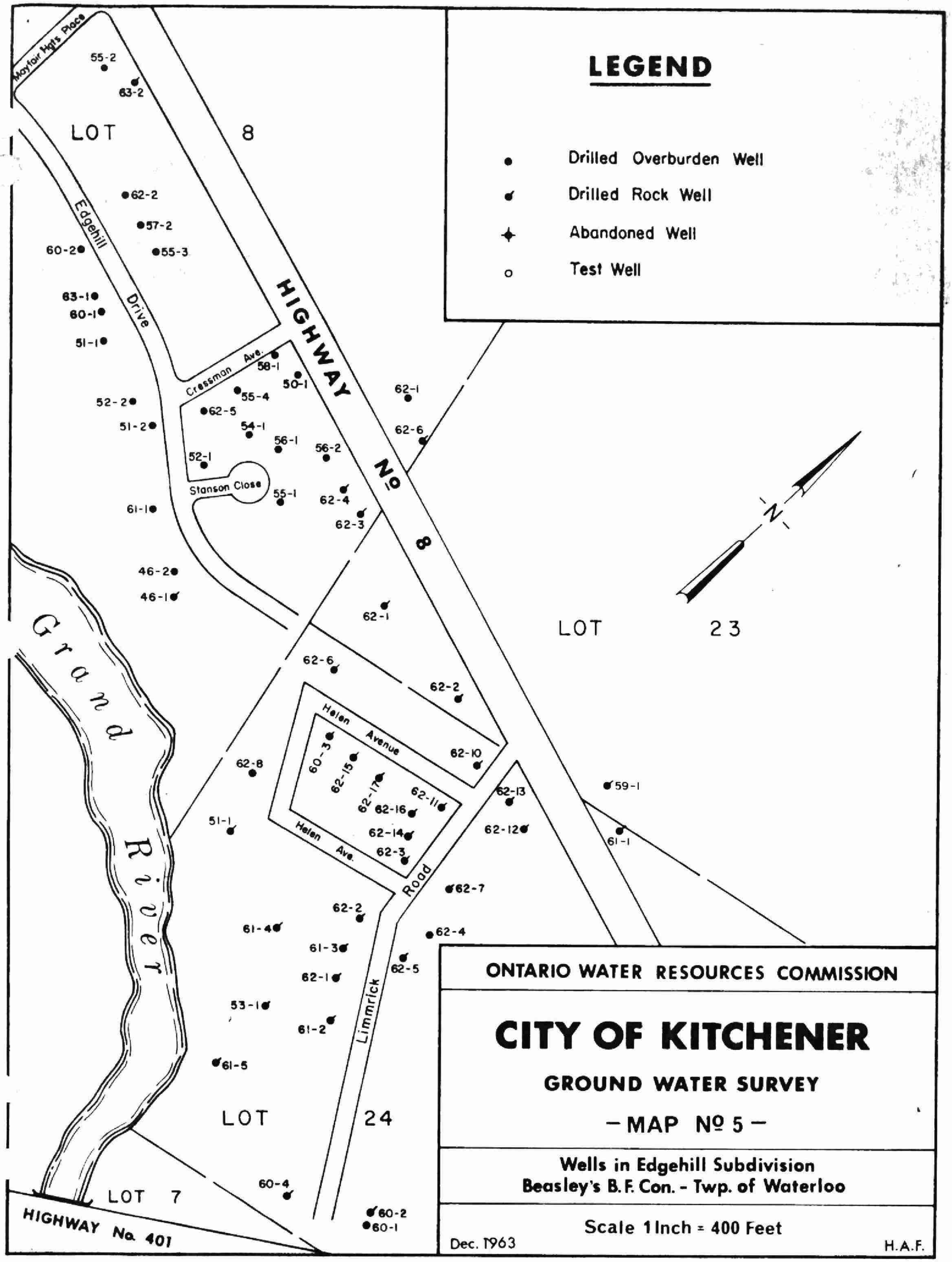
— MAP № 4 —

Shoemaker Avenue Well Field in the City of Kitchener

Scale 1 Inch = 400 Feet

Dec. 1963

H. A. F.


LEGEND
Drilled Overburden Well
Drilled Rock Well
Abandoned Well
Test Well
Mayfair Hgts Place
LOT 8
Edgehill Drive
HIGHWAY No 8
Cressman Ave.
Stanson Close
LOT 23
Grand River
Helen Avenue
Helen Ave.
Limmrick Road
LOT 24
LOT 7
HIGHWAY No. 401
55-2
63-2
62-2
57-2
55-3
60-2
63-1
60-1
51-1
58-1
50-1
55-4
62-5
52-2
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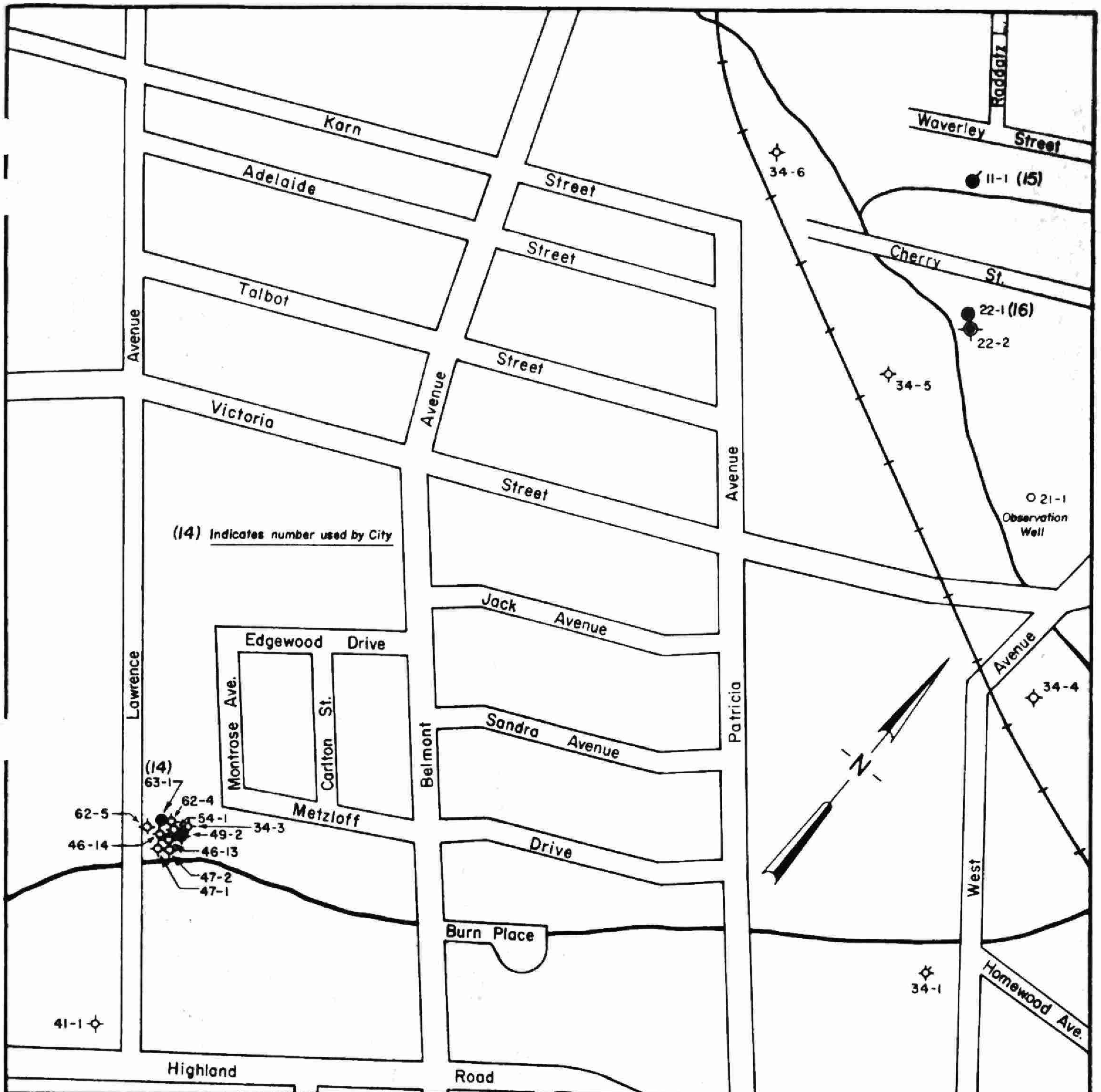
54-1
56-1
56-2
52-1
55-1
62-4
62-3
61-1
46-2
46-1
62-1
62-6
62-1
62-6
62-2
60-3
62-15
62-17
62-10
62-8
62-11
62-16
62-13
59-1
51-1
62-14
62-3
62-12
61-1
62-7
62-2
61-4
61-3
62-4
62-5
62-1
53-1
61-2
61-5
60-4
60-2
60-1
ONTARIO WATER RESOURCES COMMISSION
CITY OF KITCHENER
GROUND WATER SURVEY
— MAP No 5 —
Wells in Edgehill Subdivision
Beasley's B.F. Con. - Twp. of Waterloo
Scale 1 Inch = 400 Feet
Dec. 1963
H.A.F.



LEGEND

- Drilled Overburden Well
- Drilled Rock Well
- Abandoned or Dry Well
- Test Well
- Municipal Well

ONTARIO WATER RESOURCES COMMISSION

CITY OF KITCHENER

GROUND WATER SURVEY

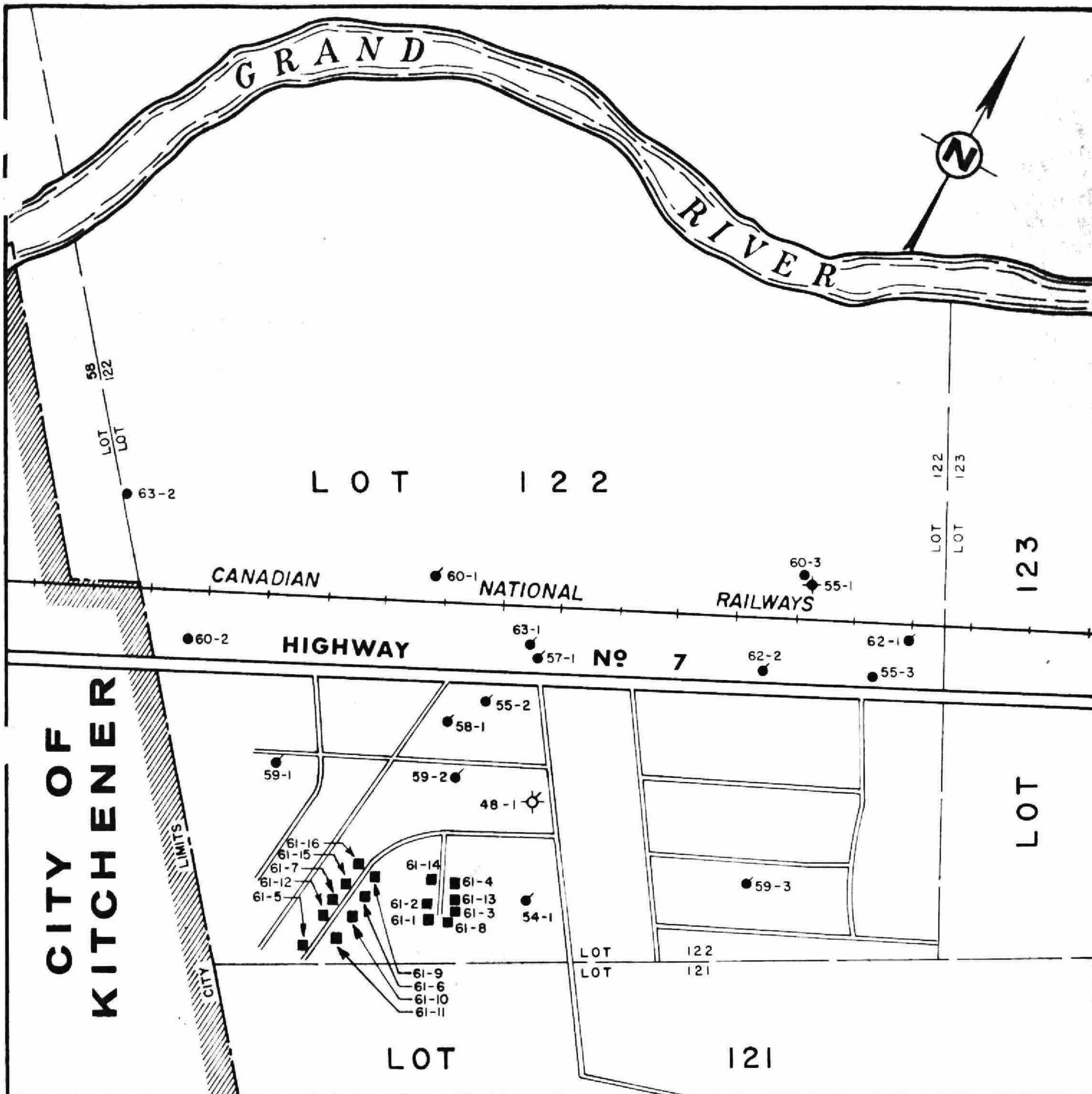
– MAP Nº 6 –

Wells near Lawrence Avenue
in the City of Kitchener

Scale 1 Inch = 400 Feet

Dec. 1963

H.A.F.



LEGEND

- Drilled Overburden Well
- Drilled Rock Well
- Abandoned Well
- Test Well
- Dug or Bored Well

ONTARIO WATER RESOURCES COMMISSION

CITY OF KITCHENER

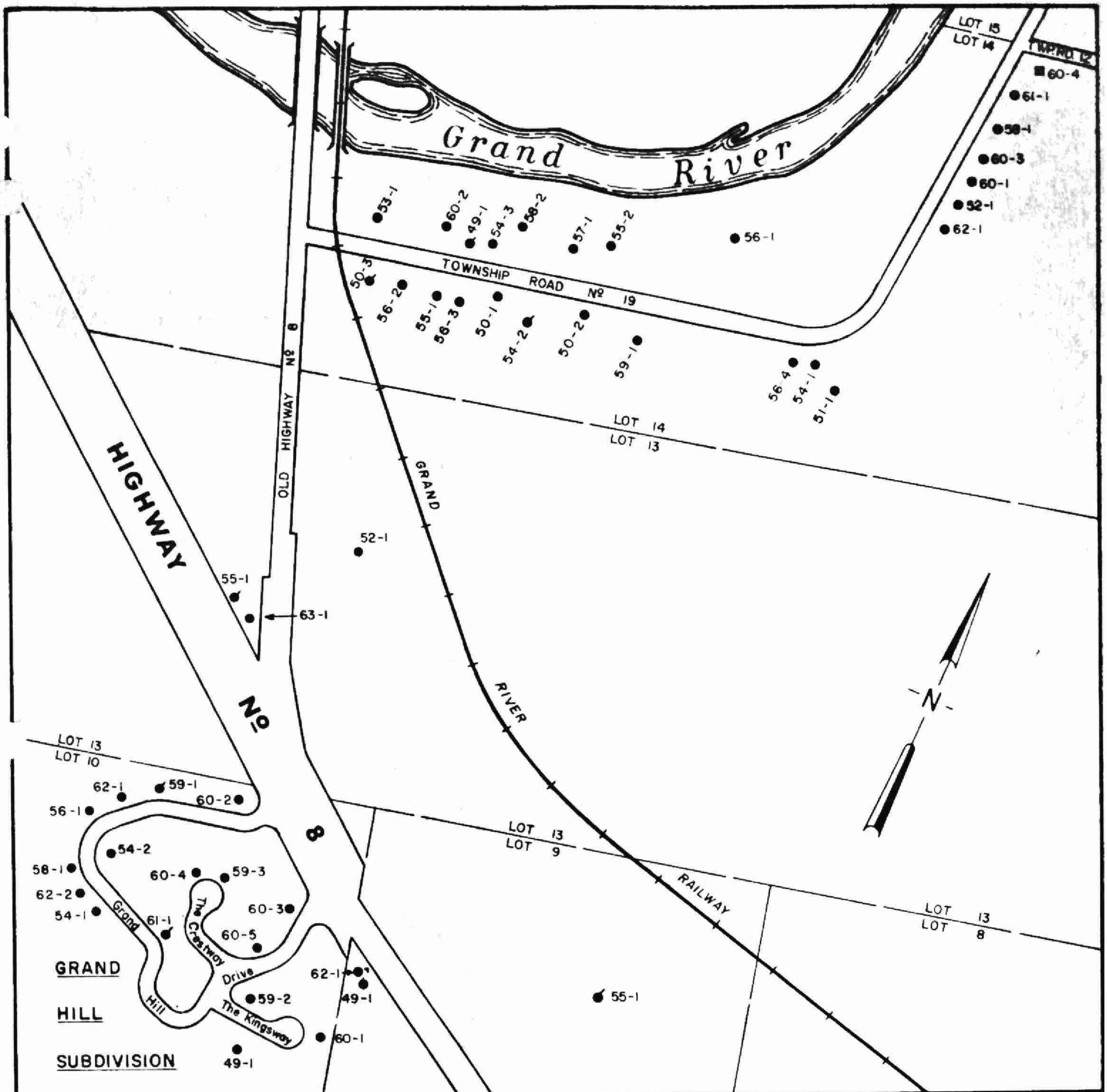
GROUND WATER SURVEY

— MAP Nº 7 —

Wells in Lot 122 G.C.T. - Twp. of Waterloo

Scale 1 Inch = 800 Feet

Nov. 1963 H. A. F.



LEGEND

- ● Drilled Overburden Well
- Drilled Rock Well
- Abandoned or Dry Well
- ○ Test Well
- ■ Dug or Bored Well

ONTARIO WATER RESOURCES COMMISSION

CITY OF KITCHENER

GROUND WATER SURVEY

– MAP Nº 8 –

Wells in Lots 13, 14, and in Grand Hill Subdivision
Beasley's B.F. Con.-Twp. of Waterloo

Scale 1 Inch = 600 Feet

Dec. 1963 H.A.F.

TABLE 2 - CHEMICAL ANALYSES

All analyses except pH are reported in parts per million

ell o.	MUNICIPALITY	Conc.	Lot	OWNER	Lab No.	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Iron as Fe	Chloride as CL	pH at Lab	Fluoride as F	Sulphate as SO_4	Free Amonia as N	Date Sampled	Aquifer
3-1	Waterloo			Waterloo PUC #4	W-615	306	242	0.10	10	7.6	0.1	58		31/1/63	Waterloo
0-1	Waterloo			Waterloo PUC S.T.P.	W-2096	1450 78	182	0.19	15	7.3				4/10/63	Rock
2-1	Waterloo			Jos.E. Seagram	W-6235	516	246	0.0	19	7.8		220	0.08	10/26/62	Waterloo
2-1	Waterloo Twp.	BNT	2	A. E. Barron	W-2991	428	226	2.2	8	7.5				5/14/62	Middle o Lower
2-1	Waterloo Twp.	BNT	8	Chalon Estates Inc.	W-1021	208	204	0.84	2	7.8				2/18/63	Middle. Lower
9-1	Waterloo Twp.	BUT		Mel Wright	W-437	1240 32	174	5.00	3	7.2				1/23/63	Over-burden
2-2	Waterloo Twp.	BUT		Ross Hamilton	W-436	1540	196	0.82	4	7.2				1/23/63	Rock
5-2	Waterloo Twp.	BBF	8	Harold Clemens	W-434	216	216	0.34	4	7.8				1/23/63	Over-burden.
3-1	Waterloo Twp.	BBF	9	K. Mart Plaza	W-2028	370 25	208	0.43	24	7.9				4/8/63	Over-burden
9-1	Waterloo Twp.	BBF	19	Gerald Hofstetter	W-432	224 26	212	0.48	4	7.7				1/23/63	Over-burden
2-1	Waterloo Twp.	BBF	23	Embassy Motel	W-2675	210	210	0.60	7	7.7				4/27/63	Rock
2-15	Waterloo Twp.	BBF	24	C.E. Zinkham	W-300	196	206	0.55	5	7.7				1/16/63	Rock
9-1	Waterloo Twp.	BBF	27	John Straus	W-430	204 27	204	0.98	3	7.7				1/23/63	Over-burden
-1	Waterloo Twp.	BBF	30	H.H. Wideman	W-431	150 59	176	0.20	trace	7.8				1/23/63	Rock
-1	Waterloo Twp.	BNS	11	R.J. Steffler	W-6231	280 28	232	0.10	4	7.8				11/12/63	Lower
-1	Waterloo Twp.	BOS	4	Cherry Gehman	W-441	710	206	3.50	5	7.4				1/22/63	Rock
-1	Waterloo Twp.	BOS	6	Harry Kinsie	W-439	1360 34	170	2.70	4	7.2				1/23/63	Over-burden

TABLE 2 -- CHEMICAL ANALYSES

All analyses except pH are reported in parts per million

ell o.	MUNICIPALITY	Conc.	Lot	OWNER	Lab No.	Hardness as $CaCO_3$		Alkalinity as $CaCO_3$	Iron as Fe	Chloride as CL	pH at Lab	Fluoride as F	Sulphate as SO_4	Free Amonia as F	Date Sampled	Aquifer
6-1	Waterloo Twp.	BOS	10	J.W. Leeson	W-440	480		218	4.35	7	7.5				1/22/63	Over-burden
1-1	Waterloo Twp.	BOS	12	Sigmund Martenko	W-6240	640		174	0.35	4	7.7				11/12/63	Middle or Lower
7-1	Waterloo Twp.	BT		A. Musselman	W-6239	240	31	228	0.35	4	7.9				11/12/63	Middle or Lower
0-1	Waterloo Twp.	BT		Doon Pioneer Village	W-6229	254		226	1.42	6	7.7				11/12/63	Middle or Lower
54-1	Waterloo Twp.	GCT	26	Waterloo PUC #5	W-616	486		194	1.52	5	7.5	0.5	410		1/31/62	
3-4	Waterloo Twp.	GCT	35	John Blazer	W-6238	270	18	234	2.56	10	7.9				11/12/63	Middle
0-1	Waterloo Twp.	GCT	46	K.W.C. #21	W-2811	272		264	0.17	7	7.8				5/27/63	Mannheim
3-1	Waterloo Twp.	GCT	102	Elton Randall	W-6247	280	22	238	0.28	9	7.8				11/12/63	Lower or Middle
-1	Waterloo Twp.	GCT	104	P.W. Wagner	W-6246	300	56	208	1.24	10	7.9				11/12/63	Rock
-1	Waterloo Twp.	GCT	108	Jos.E. Seagram & Sons	W-7001	272	55	188	0.32	5	7.6		140	0.29	12/4/62	Rock
-1	Waterloo Twp.	GCT	111	W-W Airport	W-6248	370	58	204	1.60	7	7.8				11/12/63	Rock
-1	Waterloo Twp.	GCT	115	C. Stoermer	W-6245	380	57	228	2.04	7	7.9				11/12/63	Rock
-2	Waterloo Twp.	GCT	115	Elmer Brandon	W-4325	230	20	256	0.43	2	7.9	0.2			7/24/62	Breslau
-1	Waterloo Twp.	GCT	115	Elmer Brandon	W-4326	178	19	214	0.27	5	7.9	0.3			7/24/63	Breslau
-1	Waterloo Twp.	GCT	119	Clarence Eby	W-6241	500	21	270	0.10	14	7.9				11/12/63	Breslau
-1	Waterloo Twp.	GCT	138	K.W.C. #25	W-34	220		198	----	11	8.6				12/30/63	Mannheim
-1	Waterloo Twp.	GCT	147	J.H. Sallans	W-6230	484	23	158	0.92	3	7.8				11/12/63	Lower
-1	Wilmot Twp.	Block A,I	10	Wilfred Scheidel	W-6233	210		198	0.18	4	8.1				11/12/63	Lower
-1	Wilmot Twp.	Block A,II	6	Quenton B. Hallman	W-6232	400		174	1.84	4	7.9				11/12/63	Lower
-1	Wilmot Twp.	BRS	2	K.W.C. #23	W-2814	278		252	0.10	14	7.9				5/27/63	Mannheim
-2	Wilmot Twp.	BRS	2	K.W.C. #22	W-2812	272		254	0.45	11	7.8				5/27/63	Mannheim
-1	Wilmot Twp.	BRS	3	K.W.C. #24	W-2813	270		246	0.15	8	7.9				5/27/63	Mannheim

TABLE 2 - CHEMICAL ANALYSES

All analyses except pH are reported in parts per million

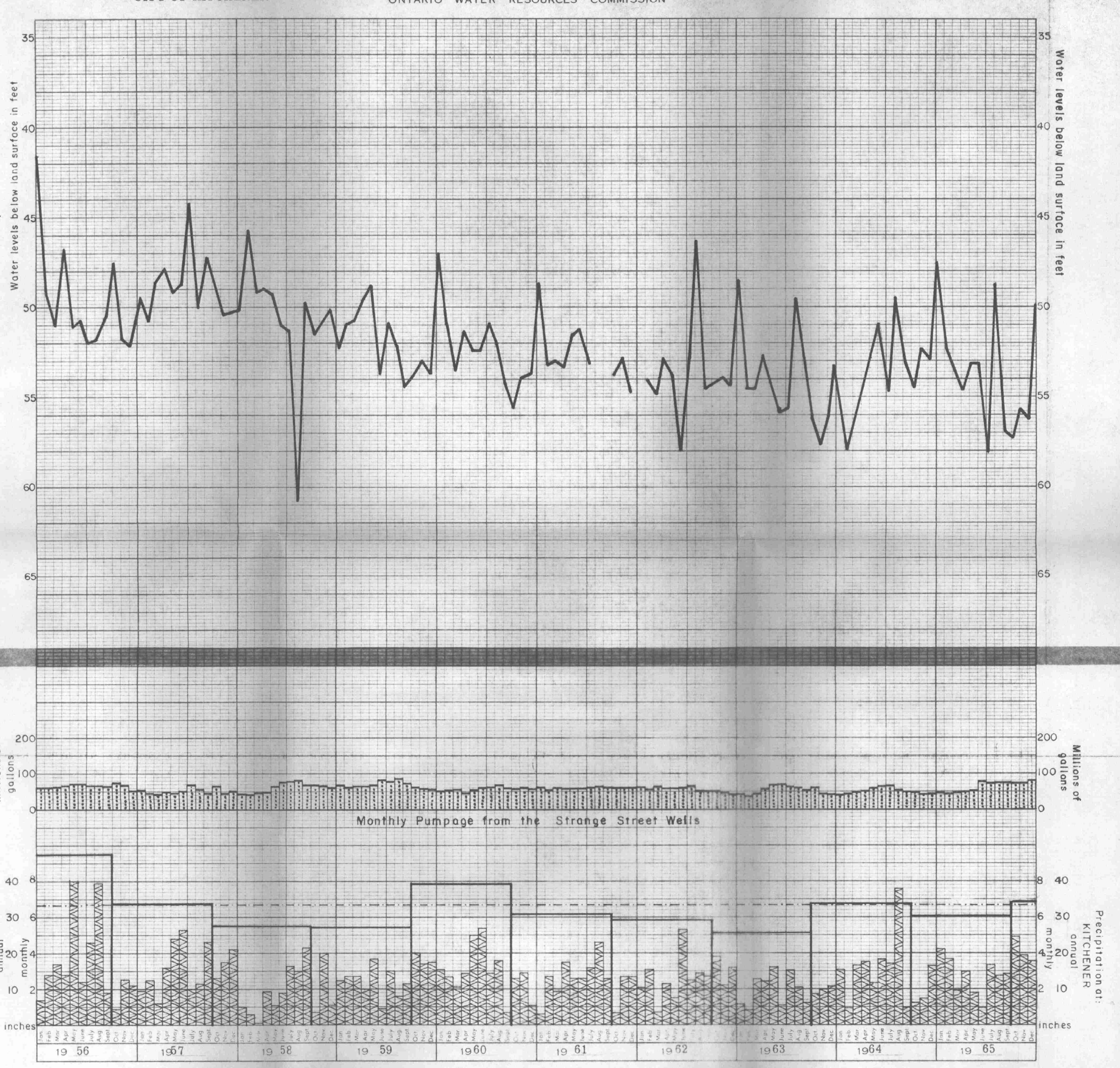
ell o.	MUNICIPALITY	Conc.	Lot	OWNER	Lab No.	Hardness as $CaCO_3$		Alkalinity as $CaCO_3$	Iron as Fe	Chloride as CL	pH at Lab	Fluoride as F	Sulphate as SO_4	Free Amonia as F	Date Sampled	Aquifer
7-2	Wilmot Twp.	ERS	1	Waterloo PUC 57-6		216	4?	214	0.6	11						StAgatha
7-1	Wilmot Twp.	ERS	3	Waterloo PUC 57-7		236		212	1.6	7						St.Agath
3-1	Wilmot Twp.	ERS	3	Waterloo PUC #6	W-617	270		240	0.38	7	7.7	0.1	39		31/1/63	St.Agath
-1	Wilmot Twp.	SRN	1	W.E. Potawarka	W-6237	270	4?	234	0.25	5	7.9				11/12/63	Mannhei
3-1	Wilmot Twp.	SRN	5	Jack Rechsteiner	W-62-36	128	47	166	0.48	6	8.1				11/12/63	Lower or Mannhei
0-1	Wilmot Twp.	SRS	7	Tend-R.Flesh Ltd	W-6235	290	4	234	0.12	22	8.0				11/12/63	Peterbur
-1	Wilmot Twp.	SRS	9	N.Swartzentruber	W-6234	270	45	246	0.08	11	7.8				11/12/63	Peterbu

COUNTY OF WATERLOO
CITY OF KITCHENER

ONTARIO WATER RESOURCES COMMISSION

OBSERVATION WELL
No. 59

G9-10141



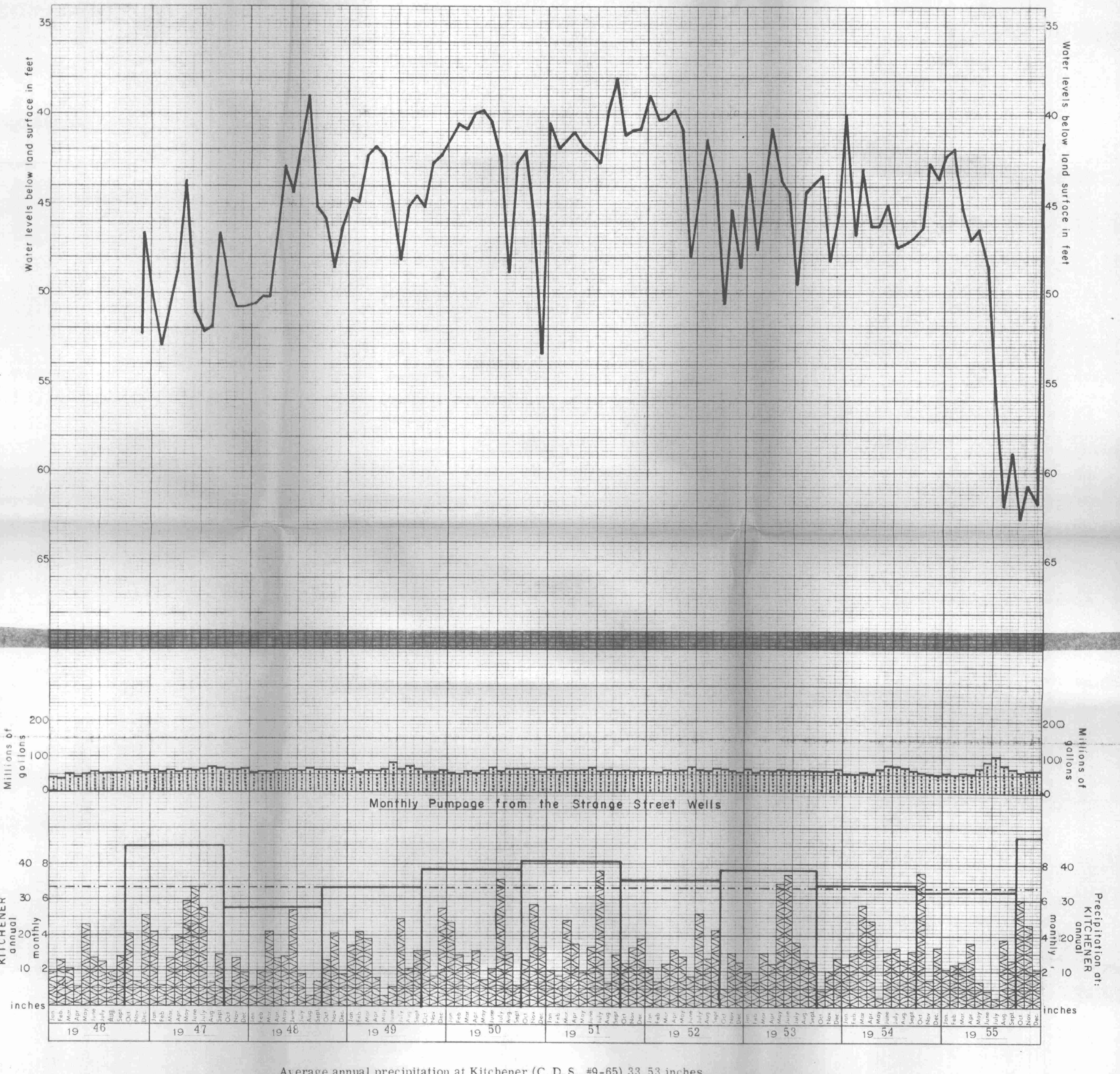
Average annual precipitation at Kitchener (C.D.S. #9-65) 33.53 inches.

COUNTY OF WATERLOO
CITY OF KITCHENER

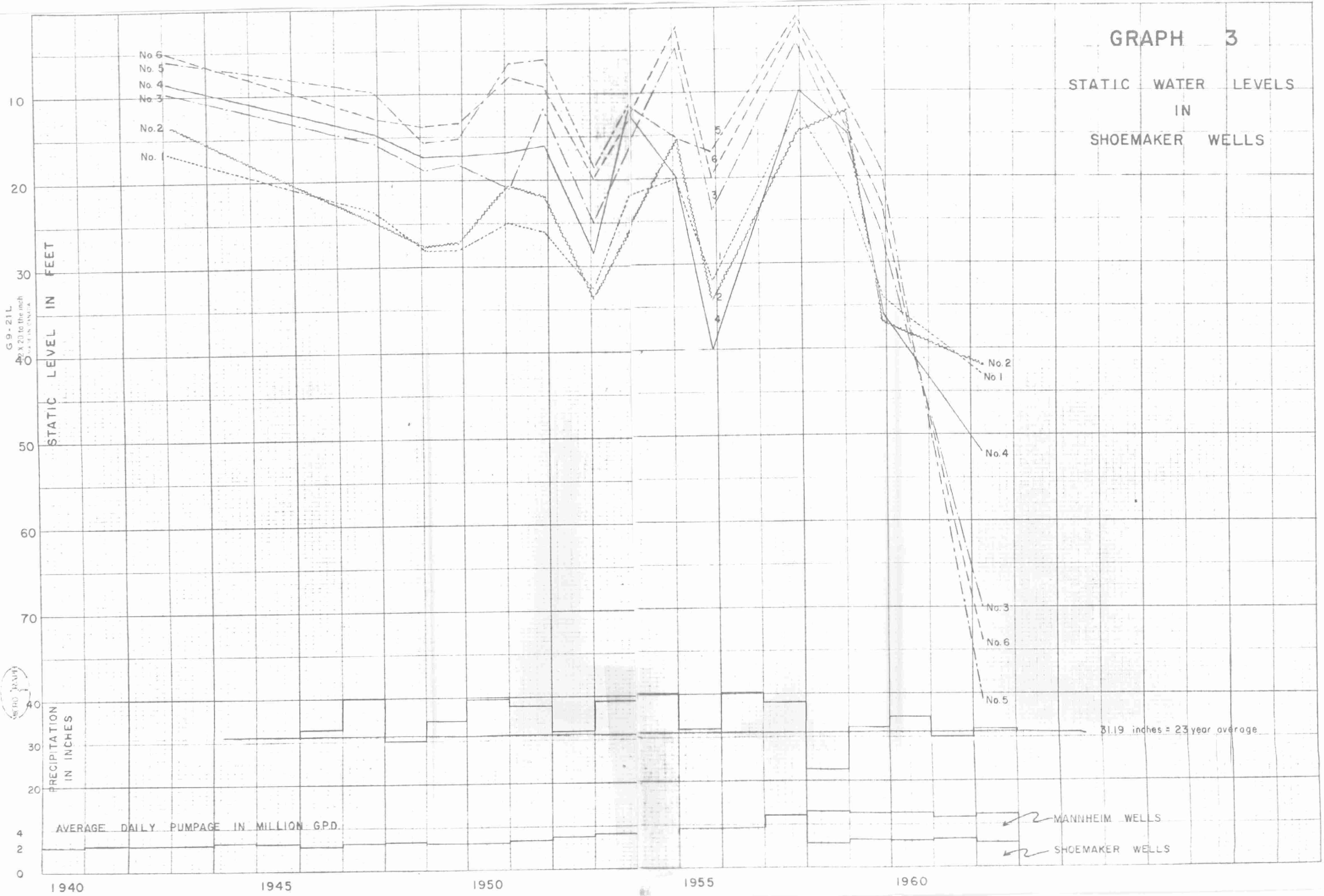
ONTARIO WATER RESOURCES COMMISSION

OBSERVATION WELL
No. 59

G9-10141

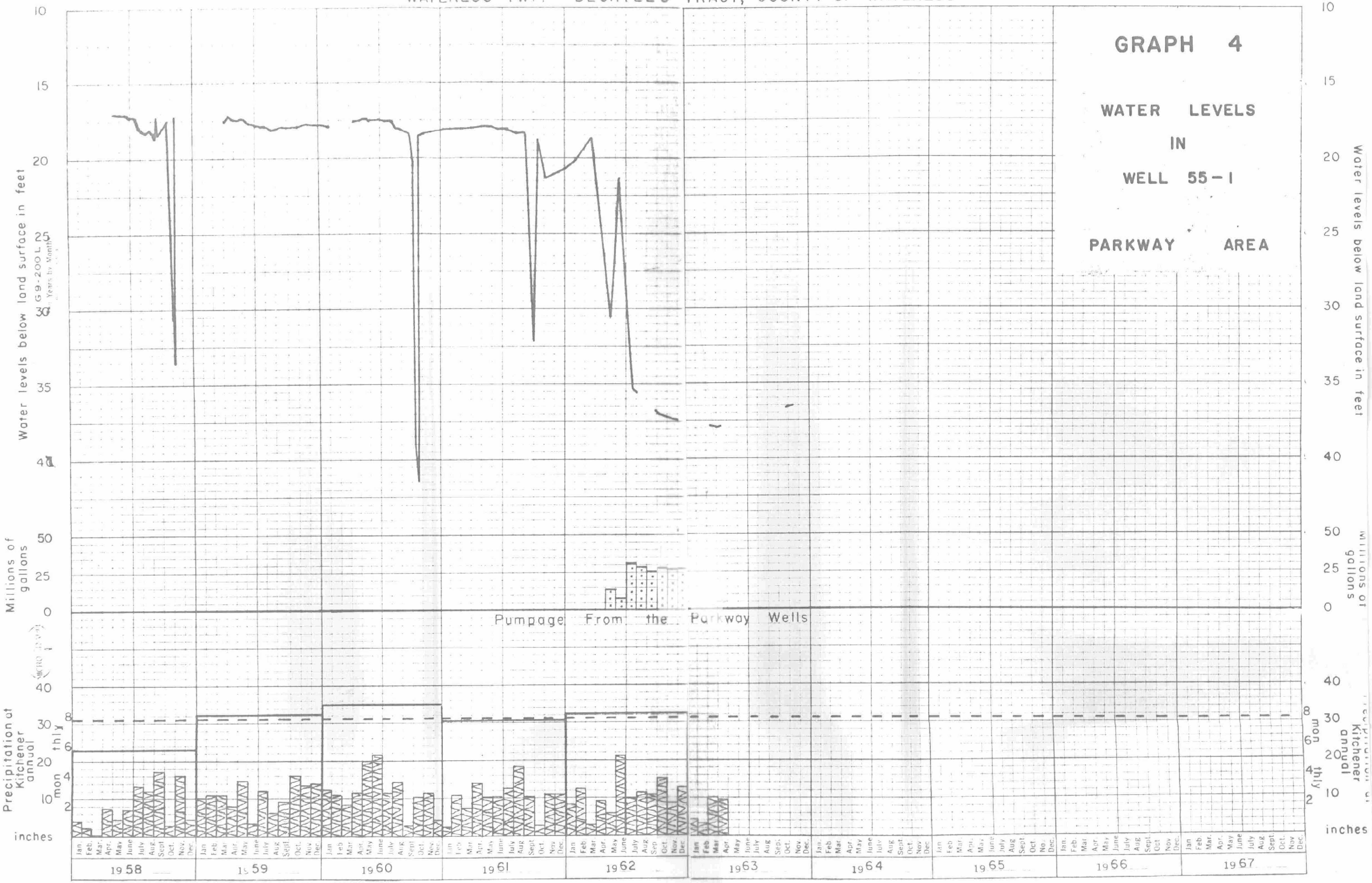


Average annual precipitation at Kitchener (C.D.S. #9-65) 33.53 inches.

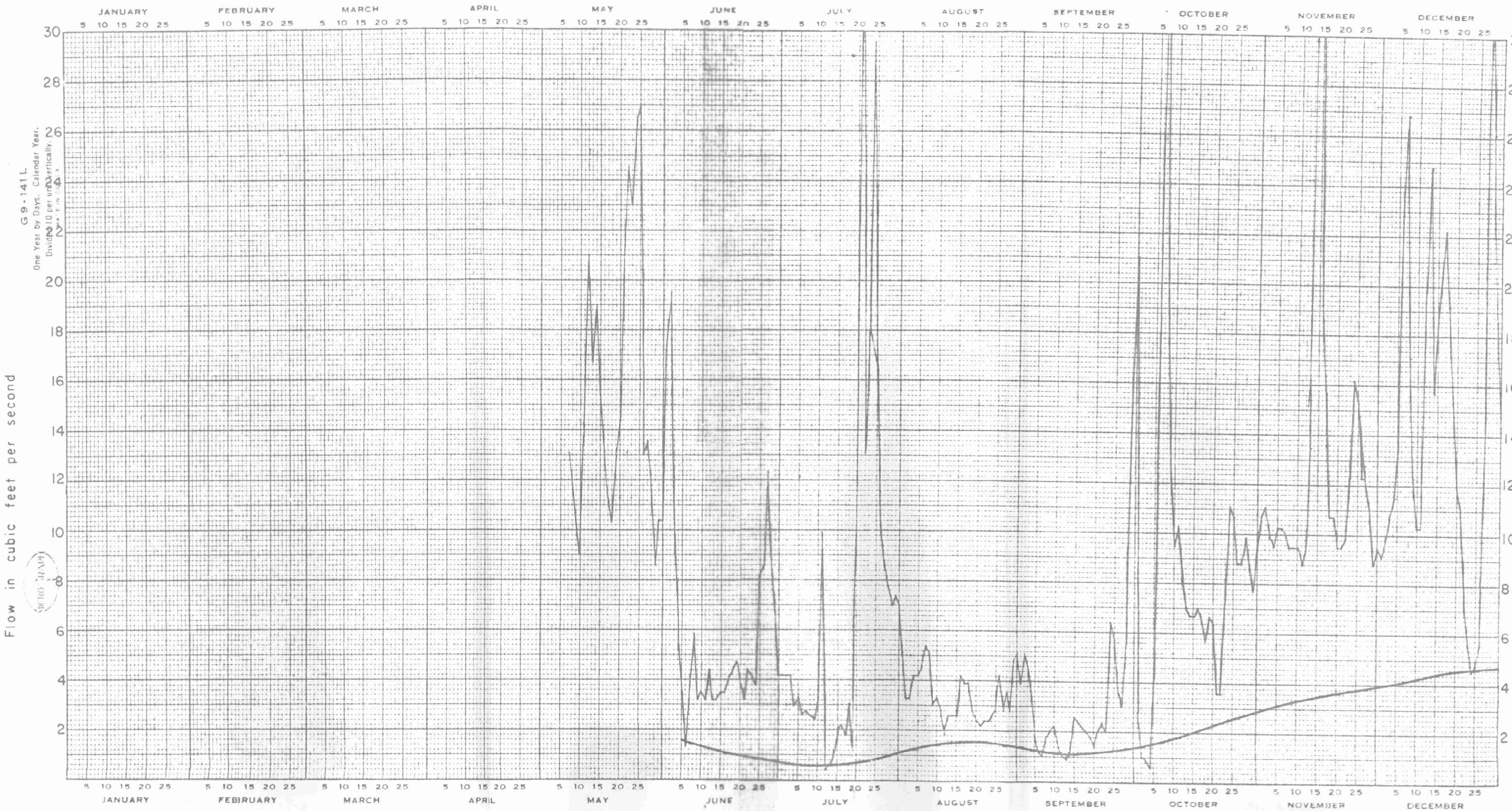

GRAPH 3
STATIC WATER LEVELS IN SHOEMAKER WELLS
STATIC LEVEL IN FEET
10
20
30
40
50
60
70
No 6
No. 5
No. 4
No. 3
No. 2
No. 1
No. 2
No 1
No. 4
No. 3
No. 6
No. 5
5
6
3
2
4
PRECIPITATION IN INCHES
40
30
20
31.19 inches = 23 year average
AVERAGE DAILY PUMPAGE IN MILLION GPD
4
2
0
MANNHEIM WELLS
SHOEMAKER WELLS
1940
1945
1950
1955
1960

OBSERVATION WELL No. 82

WATERLOO TWP. BECHTEL'S TRACT, COUNTY OF WATERLOO



Average annual precipitation at Kitchener for 23 year period 31.19 inches



JANUARY
FEBRUARY
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APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
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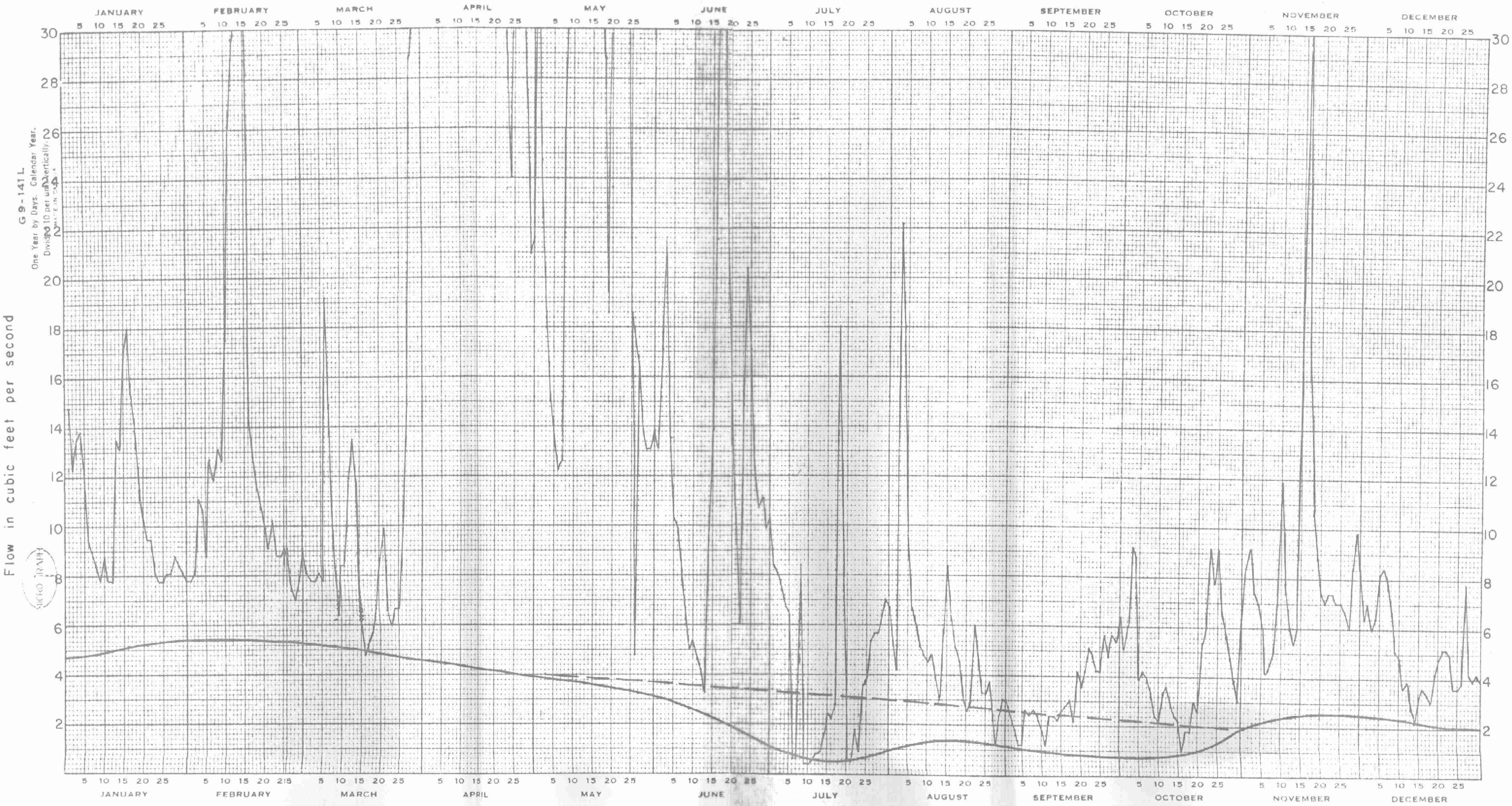
4
2
Flow in cubic feet per second
G9-141L
One Year by Days. Calendar Year.

1959


G 9-141 L.
One Year by Days. Calendar Year.
Divided 10 per unit vertically.
Flow in cubic feet per second
JANUARY
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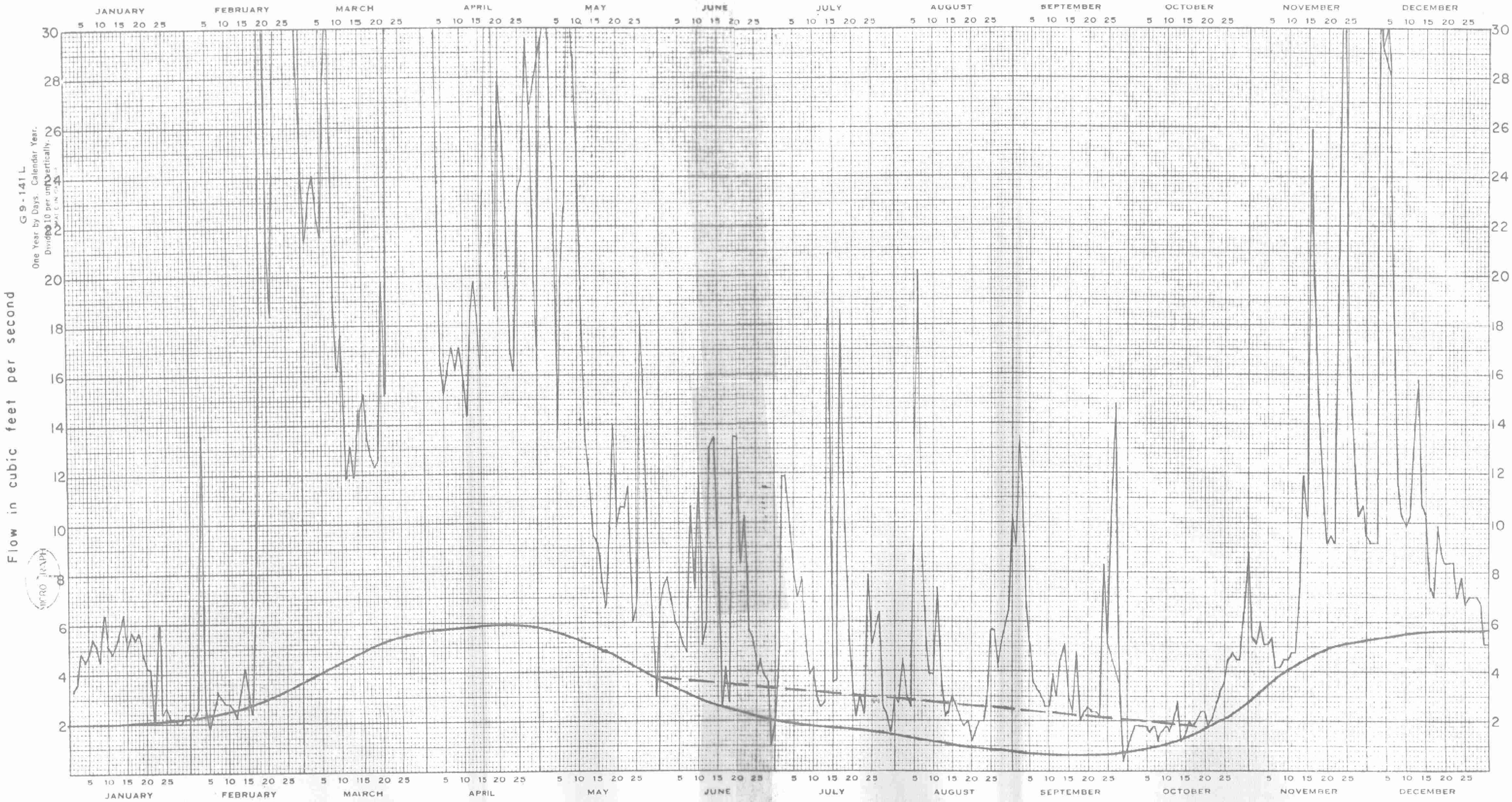
1960


JANUARY
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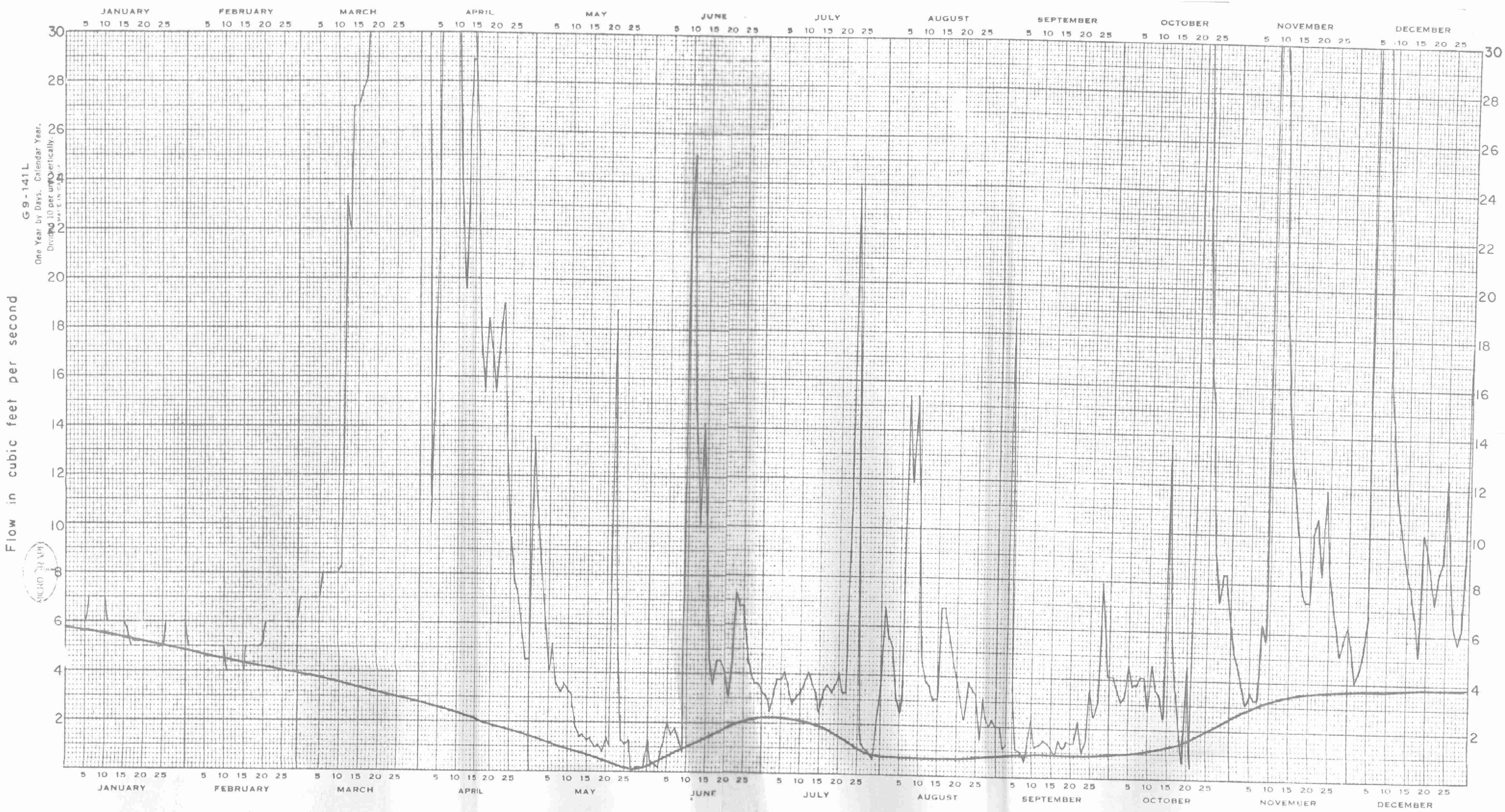
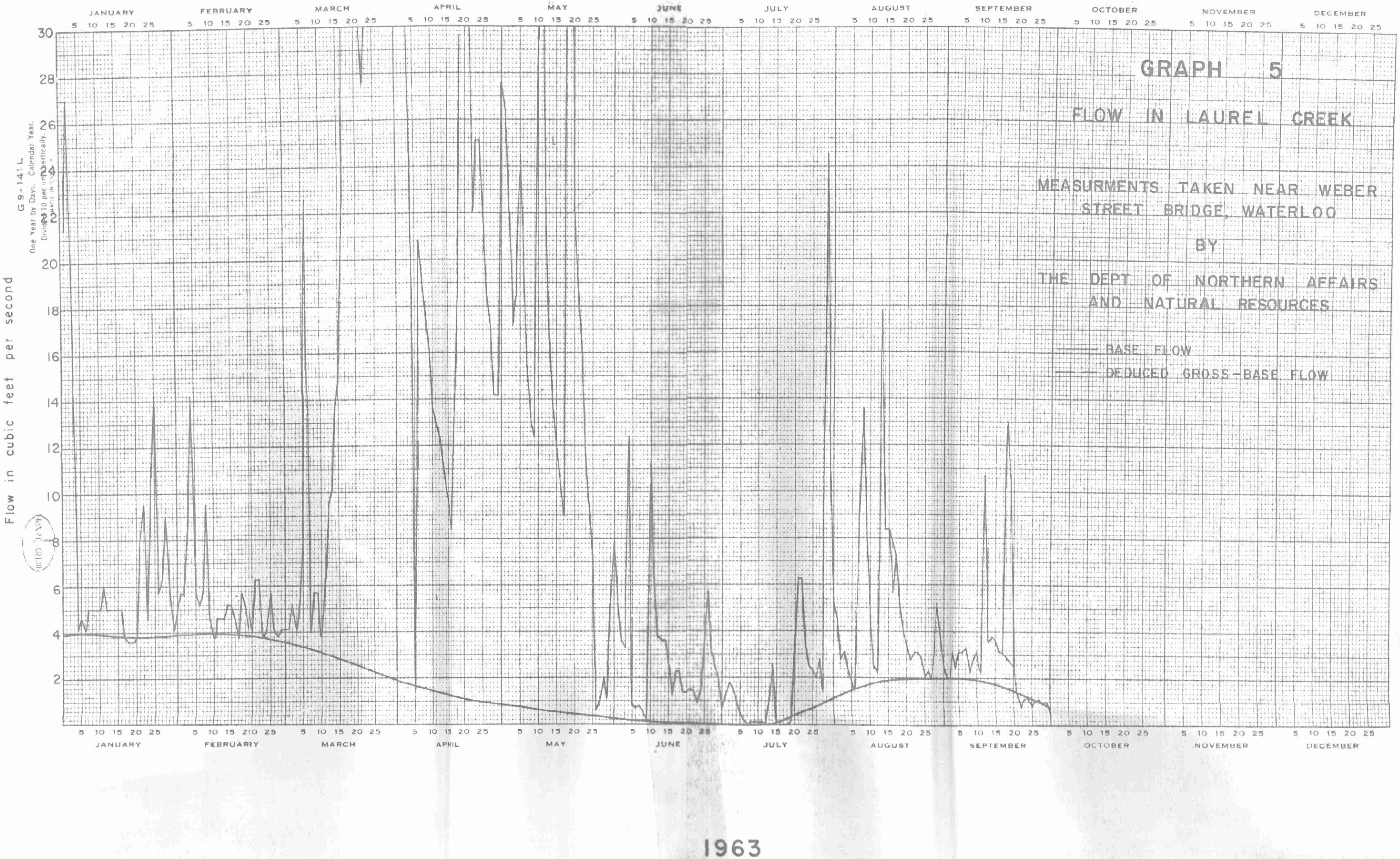
30
Flow in cubic feet per second
G9-141 L
One Year by Days. Calendar Year.
Divided 10 per unit vertically.

1961


G9-141L
One Year by Days. Calendar Year.
Divided 10 per unit vertically.
Flow in cubic feet per second
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

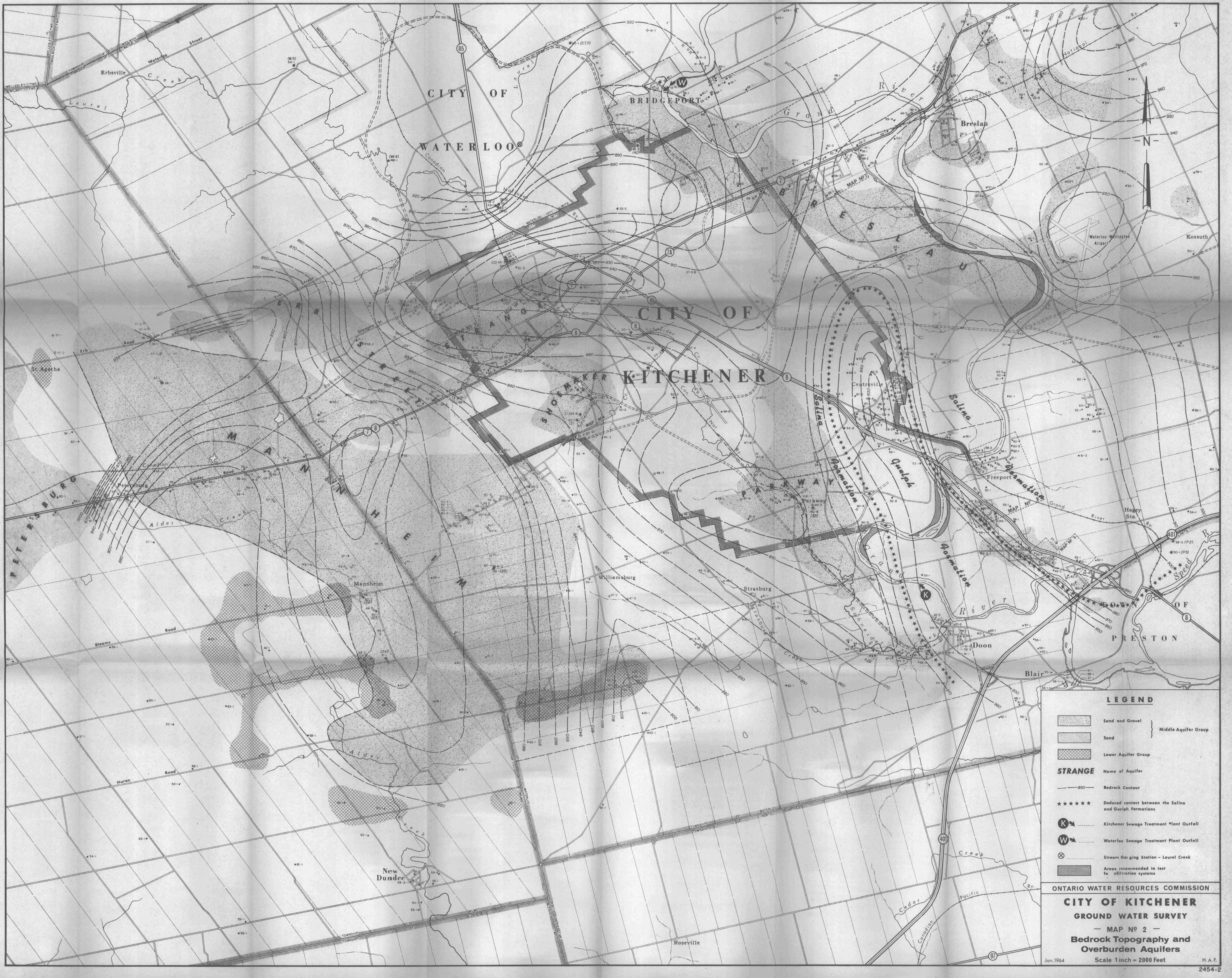
1962



GRAPH 5
FLOW IN LAUREL CREEK
MEASURMENTS TAKEN NEAR WEBER STREET BRIDGE, WATERLOO
BY
THE DEPT OF NORTHERN AFFAIRS AND NATURAL RESOURCES
BASE FLOW
DEDUCED GROSS-BASE FLOW
Flow in cubic feet per second
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
G9-141L
One Year by Days. Calendar Year.
1963


CITY OF WATERLOO
CITY OF KITCHENER
GERMAN COMPANY TRACT
BRIDGEPORT
Breslau
Centreville
Freeport
Parkway
Williamsburg
Strasburg
Doon
Blair
Mannheim
Petersburg
St. Agatha
Erbsville
New Dundee
Roseville
Kossuth
Hagey Sta.
Waterloo-Wellington Airport
WOOLWICH
WELLESLEY
WILMOT
TOWNSHIP OF WILMOT
NORTH DUMFRIES
BLENHEIM
TOWN OF PRESTON
BECHTEL'S TRACT
HIESTRAND'S TRACT
BEAN'S NUMBERED TRACT
BEAN'S UNNUMBERED TRACT
BEASLEY'S NEW SURVEY
BEASLEY'S OLD SURVEY
BEASLEY'S BROKEN FRONT
BRICKER LOT
MIDDLE BLOCK LOT
BEASLEY'S LOWER LOCK
SMALL LOTS NORTH OF PETER HORNING'S TRACT
PETER HORNING'S TRACT
Grand River
Speed R.
Laurel Creek
Alder Creek
Schneider Cr.
Canadian National Ry.
Canadian Pacific Ry.
-N-
LEGEND
Drilled Overburden Well
Drilled Rock Well
Flowing Well
Abandoned or Dry Well
Abandoned Test Well
(Obs.W.) Observation Well
Municipal Well
(32) City of Kitchener Well Number
(W4) City of Waterloo Well Number
(P5) Town of Preston Well Number
Dug or Bored Well
City, Town, or Village Boundary
Township Boundary
Survey Boundary
Lot Line
ONTARIO WATER RESOURCES COMMISSION
CITY OF KITCHENER
GROUND WATER SURVEY
— MAP № 1 —
WELL LOCATIONS
Scale 1 Inch = 2000 Feet
Dec. 1963
H. A. F.

2454-1

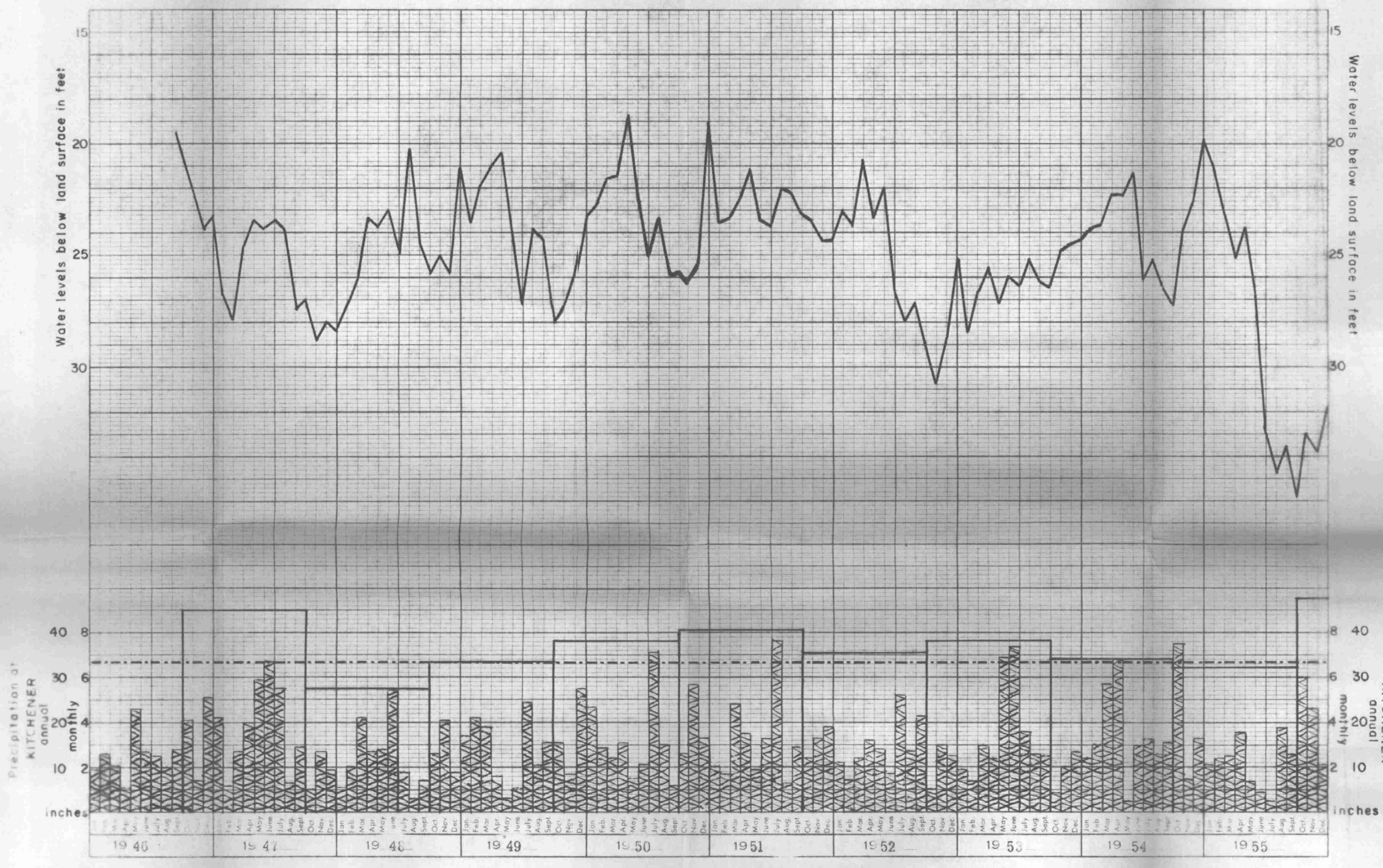

CITY OF WATERLOO
BRIDGEPORT
Breslau
CITY OF KITCHENER
ERB STREET
STRANGE
SHOEMAKER
MANNHEIM
PETERSBURG
BRESLAU
PARKWAY
Salina Formation
Guelph Formation
St. Agatha
Erbsville
Petersburg
Mannheim
Williamsburg
Strasburg
Centreville
Freeport
Doon
Blair
New Dundee
Roseville
Kossuth
Waterloo-Wellington Airport
Grand River
Speed R.
TOWN OF PRESTON
LEGEND
Sand and Gravel
Sand
Middle Aquifer Group
Lower Aquifer Group
STRANGE
Name of Aquifer
850
Bedrock Contour
Deduced contact between the Salina and Guelph Formations
Kitchener Sewage Treatment Plant Outfall
Waterloo Sewage Treatment Plant Outfall
Stream Gauging Station – Laurel Creek
Areas recommended to test for infiltration systems
ONTARIO WATER RESOURCES COMMISSION
CITY OF KITCHENER
GROUND WATER SURVEY
— MAP Nº 2 —
Bedrock Topography and Overburden Aquifers
Jan. 1964
Scale 1 inch = 2000 Feet
H.A.F.
2454-2

COUNTY OF WATERLOO
CITY OF KITCHENER

ONTARIO WATER RESOURCES COMMISSION

OBSERVATION WELL
No. 34

G9-10141



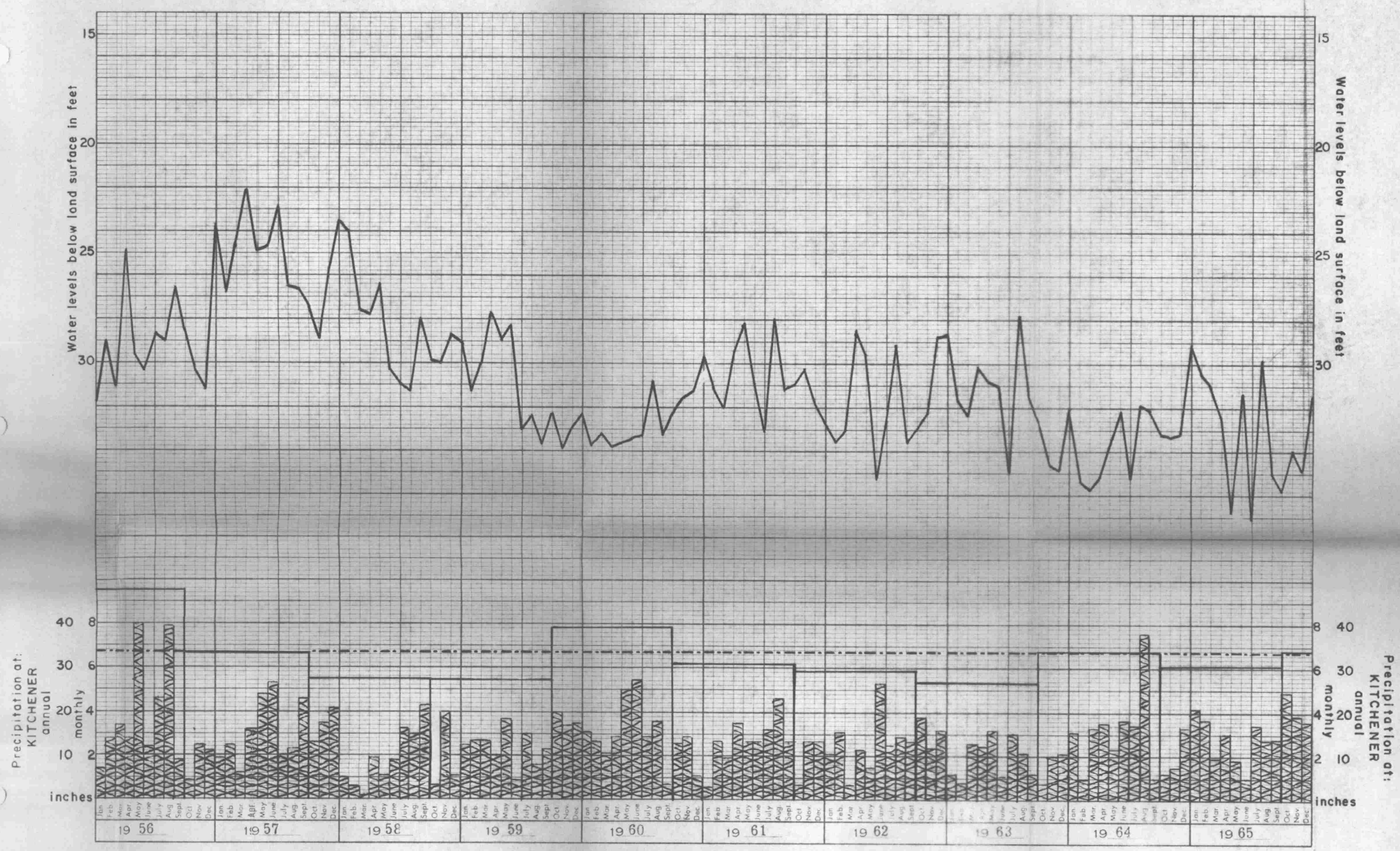
AVERAGE ANNUAL PRECIPITATION AT KITCHENER (C. D. S. #9-65) 33.53 INCHES.

COUNTY OF WATERLOO
CITY OF KITCHENER

ONTARIO WATER RESOURCES COMMISSION

OBSERVATION WELL
No. 34

G9-10141



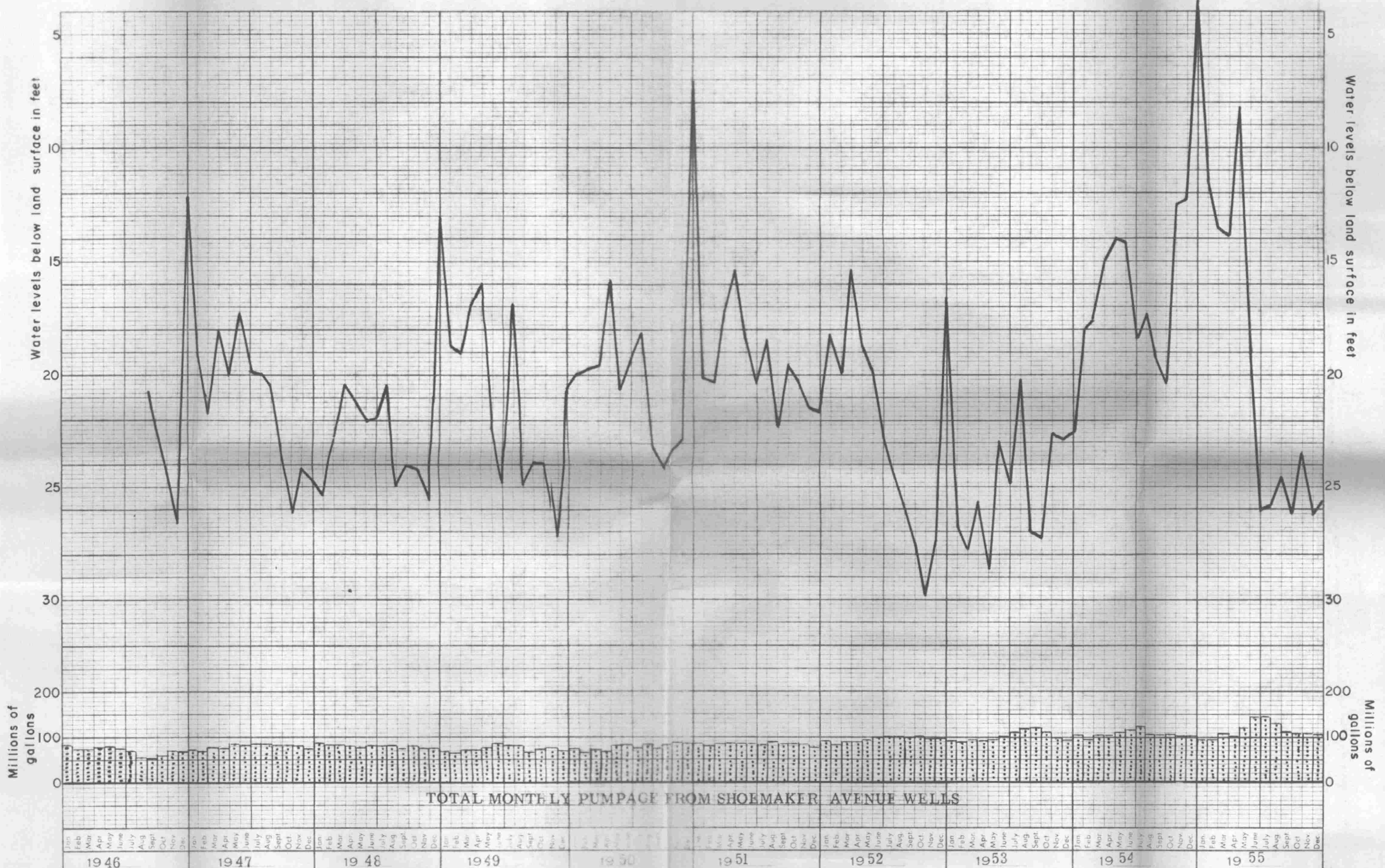
AVERAGE ANNUAL PRECIPITATION AT KITCHENER (C. D. S. #9-65) 33.53 INCHES.

COUNTY OF WATERLOO
CITY OF KITCHENER

ONTARIO WATER RESOURCES COMMISSION

OBSERVATION WELL
No. 35

G9-10141

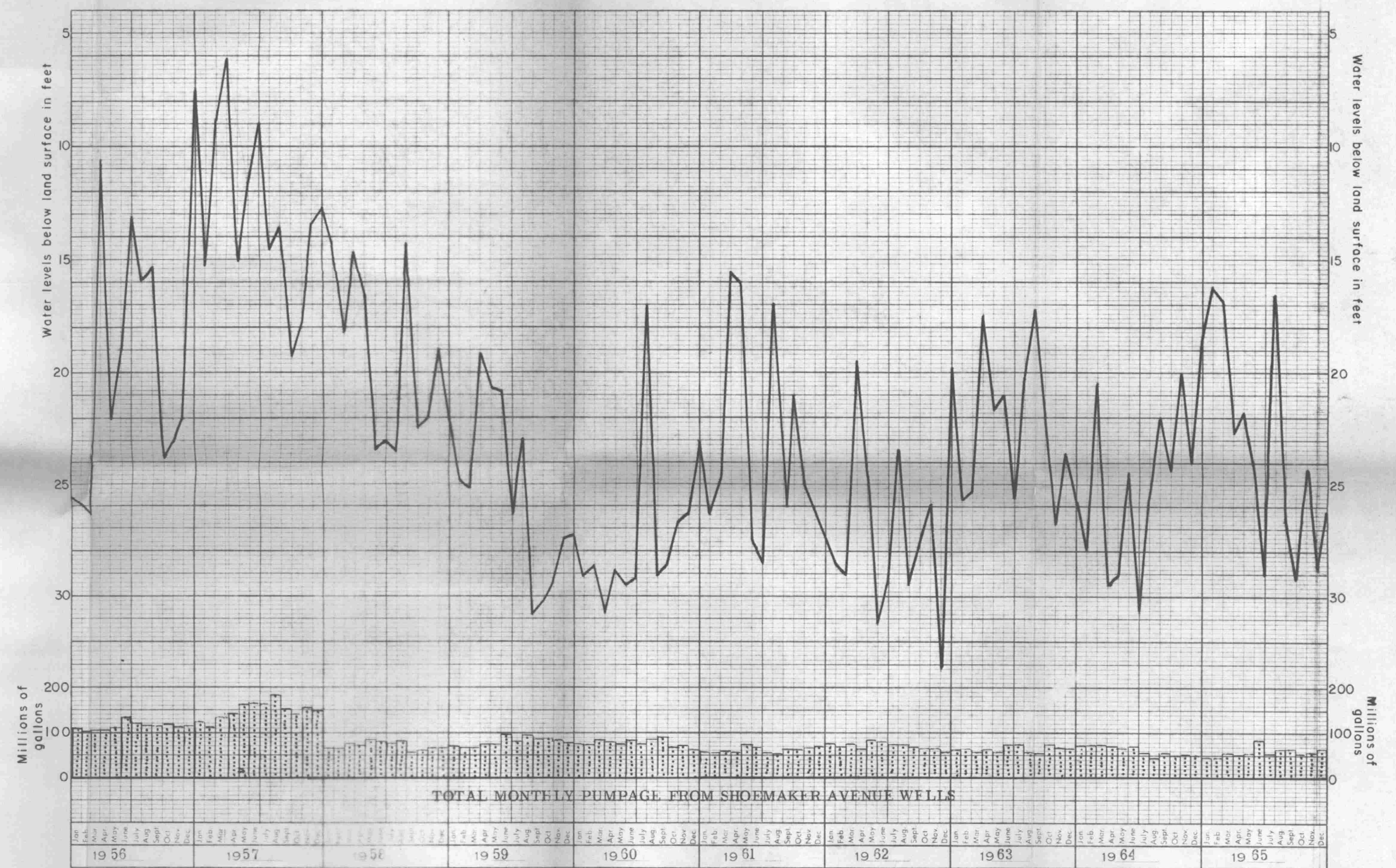


COUNTY OF WATERLOO
CITY OF KITCHENER

ONTARIO WATER RESOURCES COMMISSION

OBSERVATION WELL
No. 35

G9-10141



Date Due
